Medical Center of the Rockies LifeBoard

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Executive Summary

Lifeboard is a mechanical and computer engineering senior design project commissioned by Dr. Julie Dunn, a trauma surgeon at the Medical Center of the Rockies. The goal of the project was to replace the current pen and paper method a scribe nurse uses to record patient data during a trauma with an electronic solution. This solution consists of four main elements. The first element is an Android application which runs on a Galaxy Tab 2 tablet. This software has very similar functionality to the paper trauma flow sheets currently used by scribe nurses, but a graphical user interface (GUI) is used to input data instead of paper. Electronic data entry allows for implementation of the second main project element, the database. In addition to simply saving submitted data to the tablet's internal memory, patient information is also sent to a Microsoft Access SQL database. This database is hosted on a laptop computer with a wireless connection between the laptop and tablet to allow data transfer between the two. A TV display makes up the third element of the system, where software processes database information and displays it in a table format on a 60" TV. The final element of the project is a tablet case designed to protect the Samsung tablet from drops and impacts.

Development of the project consisted of improving the tablet GUI and TV display along with creating a tablet case. Beginning with the tablet interface, improvements were made based on feedback from the previous year's senior design group and surveys given to nurses after they used Lifeboard. A tablet was given to the Medical Center of the Rockies staff for testing purposes so that multiple rounds of feedback could be analyzed. The TV display was developed in a similar manner to the tablet GUI, but was primarily driven by suggestions from Dr. Dunn. Tablet case design and creation was influenced by a case prototype from the previous year"s design team. Multiple decision matrices were then used to decide on case features, materials, and geometry. This was followed by computer modeling of the case and FEA. The case was then

manufactured from the chosen materials and drop tested using accelerometers to gage the impact force the tablet sees.

Progress on Lifeboard throughout the year has yielded an effective tablet case and major updates to the tablet GUI and TV display. Even with this success, there are more additions and modifications to Lifeboard that were out of the scope of this year's project. These desired elements include adding more functionality and information for the tablet GUI, integrating wireless data capture between medical devices and Lifeboard, and updating the tablet case to become a professional mass producible unit.

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I. Introduction and Background

Throughout vigorous trauma resuscitations in emergency situations, no minutes are spared for miscommunication and uncertainties about timing, dosages of medication, fluids, and life-saving interventions. Traditionally, the scribe nurse of a trauma resuscitation team records each element administered to the patient using pen and paper, an inefficient, inaccurate way to collect information in these busy situations. Designed to replace this method is Lifeboard, an application for the Android operating system to be run on a Galaxy Tab 2. Overall goals of the project include faster, more reliably recorded data, easy viewing of recorded information via a large TV display, thorough data management using a dedicated server, and design of a durable case for the Galaxy tablet. The Medical Center of the Rockies trauma department seeks a technologically engineered solution to a problem that prohibits maximum efficiency and accuracy for medical processes when capturing and communicating information.

When many caretakers are simultaneously conducting crucial procedures on a patient, a hard copy recording of said procedures may not be the most suitable answer. The use of tablet PCs in health care increases clinician mobility, eliminates duplicate efforts, facilitates real-time communications, provides greater access to data, and much more [4]. Some issues in implementing tablets include a lack of well-engineered software, difficulty meeting standards

such as HIPAA that deal with patient information security, and a lack of electrical infrastructure in healthcare facilities [1].

Difficulties aside, there are few similar applications of programs and tablets targeted at the medical community. One interesting competitor that shares the goal of creating a tablet system for medical use is the Motion Computing C5t tablet. It comes equipped with laptop-spec hardware, a Windows operating system, fully sealed case, and meets multiple medical standards. Compared with the C5t, the Galaxy tablet provides a less resource intensive package with fewer physical protections and lower specs than the C5t, but it runs on a version of the Android mobile OS instead of a Windows based operating system [3]. This is an advantage because Android has large communities of app developers and programming support. It was also designed for mobile computing use, whereas Windows 7 was not. Some examples of medical Android apps are Medscape, Epocrates, and Standard dictations. The first two provide databases of information on drugs, diseases, and procedures, while the third focuses on medical interns needing to dictate information [6]. These apps are all useful for their intended purposes and provide decent references, but they do not demonstrate the same functionality for which Lifeboard will be created.

As mentioned earlier, medical centers have been slow to adopt tablets and according to Elizabeth Seislove, the Director of the Trauma Program at Lehigh Valley Health Network, and Randy Smith, the Director of the Emergency Department at Nationwide Children's Hospital, the electronic trauma flow sheet idea has lagged behind other technological advances in the health and medicine environment [2]. The increased use and reliance of electronic medical records has helped push the industry towards a unified digital system for data collection and has made solutions like Lifeboard much more beneficial. Some doctors and hospital personnel are cautious

of exploring electronic approaches mostly for reasons of cost and doubts about the superiority of new comprehensive possibilities, as well as the perceived increased in complexity when moving away from pen and paper.

Some relevant standards to the Lifeboard project deal with medical practices, software safety, and physical hardware protection. Each device included in this new Lifeboard technology will require a sufficient testing and training processes along with needing to be protected and clean. A selection of these standards include: the ASTM E2502-06 standard guide for medical transcription workstations, ASTM D4508-10 regarding standard test methods for chip impact strength of plastics, the ASTM E2457-07 standard terminology for healthcare informatics, the ASTM 32117-06 standard guide for identification and establishment of a quality assurance program for medical transcription, and the ASTM E2344-04 standard guide for data capture through the dictation process [5].

When developing and supporting new technologies such as Lifeboard, many challenges and considerations must be taken into account, including industry push-back on technological integration, similar products competing for similar purposes, and adhering to strict design standards. Many of these considerations will help the design process of Lifeboard, by providing a starting place determining how to benchmark performance. Having Dr. Dunn from the Medical Center of the Rockies as a sponsor will help this project immensely and provide our team the necessary resources to design, build, and test a fully functional trauma flow sheet replacement.

II. Design Objectives and Constraints

A. Design Objectives

Defined protocols are in place to minimize trauma chaos, but each situation brings a host of caretakers to the bedside – physicians, respiratory therapists, nurses, pharmacists, and other

ancillary staff to provide assistance. As a consequence, many simultaneous interventions are occurring, with each team member focused on their particular task. These caretakers need to communicate quickly and effectively to ensure a positive outcome. At present, all events are charted on a paper form by a scribe and overall progression of the resuscitation may not be effectively communicated or understood by the entire team. This can result in miscommunication and confusion. The goal of this project is to more efficiently keep all team members coordinated and knowledgeable about events occurring simultaneously.

The goals of this project can be categorized into two main parts: the case hardware and the hardware/software interface. Currently there is a working Lifeboard prototype with an inferior case and and hardware/software system that can be further improved. Basic information can be captured on the tablet and wirelessly transmitted to a server which displays the information on a second interface. Overall, the project needs to collect all resuscitation activities more effectively, and provide a more robust tablet protection case. The software/hardware interface must be designed to capture information as efficiently as possible and to broadcast that information easily. For the case, many aspects are involved to advance its efficiency such as its manufacturing and durability cost and its verifiable durability and weight.

Justifications are required for validity of each of the numerical project targets of the objectives. The total cost of the case was advised to be one-third or one-fourth of the total income of $4,500, so the target for the cost is less than $1,125. The group chose to use the last three-quarters of the funds for everything that is not the case, such as electronics. The average height of women in the US is five feet and 3.8 inches and the average height of men in the US is five feet and 9.3 inches[7]. Seen as how only a slim 9.6% of nurses are male and scribe nurses are the part of the trauma team who will be using the Lifeboard, five feet was chosen as the

target for the case durability drop tests [8]. The case weight target is less than 4 pounds including the tablet after taking into account the maximum tablet usage length during trauma procedures and how heavy an object the average human is allowed to carry. While the tablet on its own weighs 1.28 pounds and the scribe nurse will be standing with Lifeboard at hip height for 30 minutes to an hour and fifteen minutes. According to the sponsor Dr. Dunn, as of now the scribe nurse has around 15% entry error because of missing information during the trauma procedures. A detailed summary of the project objectives can be found in the following Table 1: Design Objectives.

Objective Name	Priority Rating	Method of Measurement	Objective Direction	Target
Cost of Case	4	Funds used to produce case ($)	Minimize	<1,125
Cost of Electronic Hardware	4	Funds used to buy electronics ($)	Minimize	<3,375
Case Durability	5	Drop tests (ft)	Maximize	3’
Case Weight	4	Including tablet (lbs)	Minimize	<4lbs
Data Entry Speed	5	Minutes	Minimize	<1hr
Data Entry Error	5	Scribe nurse entry error	Minimize	<5%

Table 1: Design Objectives

B. Design Constraints

The design constraints heavily coincide with the project objectives. The justifications for the constraints are also greatly related to the objective justifications and originate from the similar reasoning. The cost of the inclusive project needs to definitely be less than the income of the project budget of $4,500. The determined reasonable durability drop test success height is four feet similar to the previous description of the average scribe nurse height. The case weight needs to be considered taking into account the varied maximum tablet usage length during and

after trauma events. The user-friendly ability of the app interface needs to encourage faster input than the 30 minutes to an hour and fifteen minutes a trauma process could take with a fifteen to thirty minute additional time it takes the scribe nurse to re-enter and check data. Time stamps and exactly how many liters of a fluid are examples of error that occurs during the recording of updates. Error is approximated to be 15% so a constraint would aim towards a smaller percentage of total error than the current method of entering information into a hard copy trauma flow sheet. Through the use of electronics and programming knowledge, wireless display connectivity needs to be executed successfully. A detailed summary of the project constraints can be found in the following Table 2: Design Constraints.

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This includes flow rates of fluids in and out of a patient wirelessly acquired via Fluonics flow meters. A detailed summary of the project constraints can be found in the following Table 2: Design Constraints.

Constraint Name	Method of Measurement	Limits
Cost	Funds used	<$4500
Durability	Drop test (ft)	3 Feet
Case Weight	Including tablet (lbs)	<=5lbs
Data entry speed	Minutes	<2 hrs
Data entry completion	Incompletion	<5%
Wireless Display Connectivity	Implemented or Not Implemented	Implemented

Table 2: Design Constraints

III. Design Summary

The current design of the Lifeboard consists of three primary areas - the tablet case, tablet interface, and the server/display interface. A new design for the table case was designed using a preliminary design from previous project team that is comprised of a cross brace of rigid material and four impact-absorbing corners. Improvements to the case include customized corners specifically designed to hold the tablet and cross brace together, a latching system to hold the corners together to replace the rubber band in the previous design, and a hand attachment on the back of the case to ensure security during use. A prototype for this new design was manufactured to test the functionality of the new corner attachments and hand strap design. To improve the computer hardware design of the system, a permanent server was acquired and all necessary server and database software was installed and calibrated on the machine to maintain the link between tablet and hospital display screen, eliminating the need for a personal computer for the system and moving the system one step closer to utilizing the hospital's own server and database. Additionally, a video module was purchased to combine the server

data and ECG display onto one large display screen. Finally, a new version of the tablet user interface was designed and implemented to address many of the improvements desired for the original user interface, making it easier to use, more accurate, more flexible, and wider in application.

IV. Design Decisions

A. Case Design

The final design of the case was considered based on potential trauma room activities that could result in tablet device damage, such as dropping. Design decisions were initially conceptualized by referring to the previous senior design team's software and tablet case design. Beginning with case design, the three previously manufactured prototypes including those from last year were analyzed for strengths and weaknesses. After brainstorming sessions and two Pugh Matrices, a clear design winner was chosen in the form of an improved version of the previous team's final prototype. After it was decided to improve this design, a morph chart was created to lay out different renovation possibilities.

To do this, the case design was broken into sub categories such as cross brace design, corner design, arm strap, etc. Again, this is more clearly described by the morph chart shown below. Following these decisions, prototypes were created utilizing 3D printing for each corner section of the case, and acrylic sheets were purchased in order to create the cross brace. The acrylic cross brace was decided upon mainly due to time constraints to provide a proof of concept case design.

Morph Chart				
x brace material	carbon fiber	fiber glass	aluminum	
corner piece (material)	silicone	impact gel	D30	
corner piece connection to x	screw	clip	molded	
strap material	nylon	velcro	silicone	elastic
corner piece shape	square	rounded	partially rounded	
strap connection to x	bolt	stud/notch	loop	clip (rotating)
strap connection to itself	loop	velcro	D-rings	Belt-style
x brace material	carbon fiber	fiber glass	aluminum	

Figure 1: Morph chart for material selection

i. Final Concept

The final case design is constructed of three main components: the cross brace, the exterior plastic corners, and the interior corner foam. Geometric modeling for the Lifeboard project was constructed using the program CREO. Assembled and other views of the case for the Samsung Galaxy Tab II can be found in **Figures 2 and 3**.

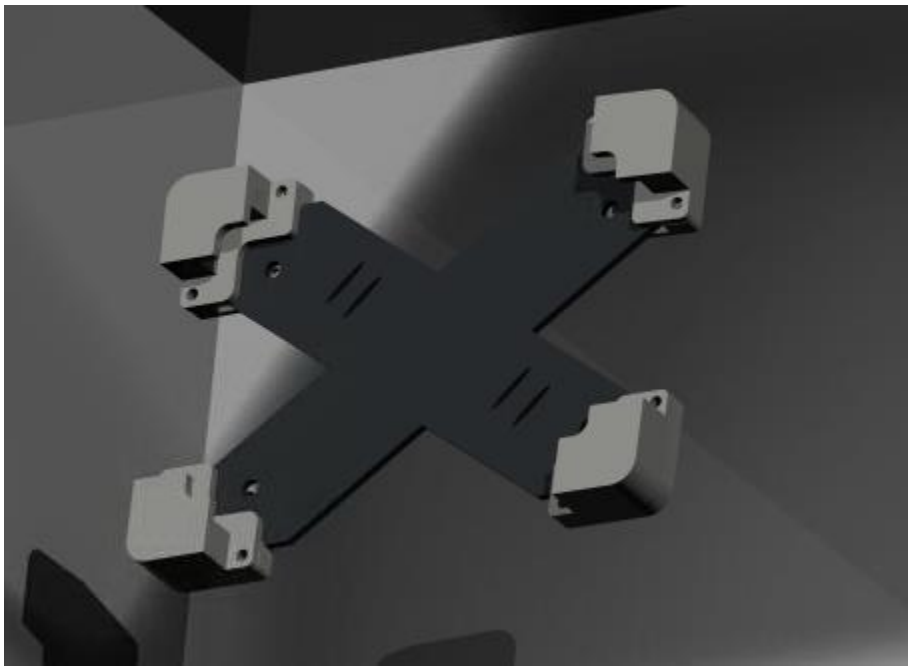


Figure 2: Case Concept Assembly

Two very important concepts to consider when designing impact protection are the impulse time and the area under impact. The longer the time duration of initial contact between

the dropped object and the fixed surface, the softer the force effectively will be, given that the duration is not too long for fear of amplification. As for area, the impulse force will be more harsh with a smaller area during impact. Keeping these facts in mind, our case concept first and foremost protects the corners of the tablet as those are the most vulnerable sections if dropped to the ground after comparing impact areas.

The 'x' cross brace shape is intended to channel impact forces away from the tablet and instead through the cross brace itself. This functionality, combined with impact absorption due to the corner pieces will greatly increase the ability of the tablet to withstand impacts.

The purpose of the FMEA analysis for the tablet case was to find design elements that could be improved or were likely to fail. Table 3 shows the elements that were analyzed. Of particular note is the case cross brace. As this analysis was done on an acrylic cross brace, the final version made of carbon fiber eliminates the potential issues documented in the FMEA. After fabricating and testing the cross brace, failure is extremely unlikely and no failures were reported during testing. The case corner pieces also did not show any signs of stress or cracking after testing, and remained solidly attached to the case. This is due to the highly impact resistant UHMW material chosen for the corners combined with a bolted together two piece corner design.

FMEA Number	Item	Potential Failure Mode	Potential Causes / Mechanisms	Local Effects of Failure	Next Higher Level Effect	System Level End Effect	Estimated Probability of Occurrence (P)	Estimated Severity (S)	Detection	Detection Opportunity Period (O)	Risk Level (P*S)	Actions for Further Investigation/Evidence	Mitigation/ Requirements
Case													
C1	Wrist Strap	Strap attachment to tablet backing plate breaks	High lateral or vertical impact to case causing tension to be placed on wrist strap. Fatigue.	Loss of use of arm strap	Possibility of damaging case backing	Loss of use of arm strap, damage to case backing, increased fatigue and slower data entry speed a consequence	C (occasionally) This rating depends on the strap attachment method chosen	IV (moderate) User will lose use of wrist band an possibly drop tablet, causing possible case damage	User may see strap begin to separate from case backing	5 (Low) The failure will likely be undetected	Moderate	Solidify decision for attachment method to case.	Add protection to strap attachment points. Use largest attachment area possible to spread impact forces
C2	Attached Corner	Clip mechanism breaks.	Fatigue. Impact to clip mechanism. Improper installation of corner	Corner piece will not attach to case (worst case scenario)	Tablet will not be held inside case	Case becomes ineffective at fully protecting the tablet for its intended purposes.	B (remote)	V (critical) causes loss of main functionality	Stress marks may be seen at the base of each side of the clip mechanism. Bent clip components indicate damage	3 (high) Failure will likely be predicted before occurring	High	N/A	Vary width of clip "tabs" to reduce stress. Fillet base of tabs to reduce stress. Vary thickness of section clips are inserted into to prevent failure.
C3	Case backing plate	Backing plate cracks	Stress from impacts. Material imperfections	Impact absorption capabilities of case will be negatively altered, possibly negated	Corner pieces will become unattached to case	Entire case will fail and no longer protect the tablet.	B (remote) This decision depends on the backing material, with planned material of carbon fiber this failure mode is unlikely	VI (catastrophic) (worst case scenario) causes complete loss of case functionality	Small cracks or stress lines may be seen in the backing plate material	5 (low) The chance of finding cracks in a carbon fiber backing plate requires the user to very carefully inspect the backing plate	Unacceptable	Material type for the backing plate must be decided upon to make the analysis accurate. Currently it is based upon carbon fiber (no fiber count or weave has been specified)	Fillet all intersecting edges that come to a point to reduce stresses at junctions. Verify layup and fabrication techniques leave no manufacturing defects in the material.

Table 3: FMEA Analysis

B. System Architecture

The overall system design is comprised of three devices - the tablet for data input by the scribe nurse, a server to save, store, and manage all data sent to it, and a large display monitor for displaying the information from the database. The tablet application collects data from user input on it's interface and stores this information locally on the tablet as well as the server. The server maintains it's own self-generated Wi-Fi (IEEE 802.11) network that the tablet connects to. The server hosts a SQL database for storing all medical records handled by Lifeboard. When data is collected on the tablet the applications wirelessly communicates with the server and alerts a server program, that executes the corresponding query in the database file, writing the content to the database as soon as it is added on the tablet. Subsequent edits and deletions of data on the tablet interface propagate these changes to the database in a similar manner, meaning that all data changes executed on the tablet are instantly mirrored in the database.

While data is being transmitted to the database, a second program actively reads the information stored in the database and formats this info into a Java application displaying lists of interventions, fluids, and drugs. The server is connected to the large display monitor via VGA or HDMI to display this application for everyone in the room to see.

C. Tablet Interface

To improve the tablet interface, the previous design was discussed with hospital staff and tested and based on this work a number of improvements were identified. This included making general data entry easier and more flexible, adding more content to the tablet for capture, and

dynamically editing and deleting data entries on the tablet interface and in the database. To improve usability of the tablet, drop-down menus previously used for interventions, fluids, and drugs were replaced with large, individual buttons for each option, making it easier to select the correct option the first time. Several small changes were implemented into various interventions, fluids and drugs to further reflect the applications of these options and to make it easier and more intuitive to input information. Additionally, an additional tab combining commonly used interventions, fluids, and drugs was implemented. See **Figures 4-5**.

The entire system was upgraded so that all information that was added on the tablet could also be edited or deleted, all from the tablet's interface. Editing and deleting was fully propagated to the database and display screen to ensure that all changes are updated for everyone in real time. Both of these processes are done by choosing an entry on the history tab of the interface and selecting the edit or delete option for that entry. In the case of the delete function with entry will be erased immediately without any other actions involved. In the case of the edit function the corresponding dialog for that particular entry will be called to re-enter and edit the content for that entry before being re-saved into the system. See **Figures 6-7**.

Finally, reference sections for burns and ACLS protocols and procedures were added for additional use during trauma scenarios. The ACLS reference section is broken into four tabs displaying four ACLS algorithms for diagnosing and treating patients with cardiac issues. See **Figure 8**. The Burns reference tab includes the burn area table of values dictating the size/seriousness of each burn based on the area of the body and age of the patient as well as a front and back view for burn reference and Parkland's Formula for treating burn victims. See **Figure 9**.

D. Display Interface

The TV Display for Lifeboard consists of several software components used for designing and using the graphical display. The first of these tools is the Netbeans IDE combined with JDK 1.7. Netbeans is a free development environment that permits designing the TV screen using a graphical "drag-and-drop" style interface. The Java Swing library is used to develop the display. The second, and critical, part of the Lifeboard TV software is the JDBC-ODBC Bridge that allows SQL queries in Java to query the Microsoft Access database. Documentation for this bridge mentions that it will be eliminated in JDK 8, and more information can be found by visiting the oracle technotes webpage. Using Netbeans along with the JDBC-ODBC Bridge is the framework for taking information from the Access database and displaying it in an organized manner.

The design of the TV display is comprised of four sections, as seen in **Figure 10**. The Fluids and Drugs sections are both larger than Interventions simply because they are used more often than Interventions. The blank spot below the Interventions tab is for a live EKG display. Among these sections, the Fluids is the most complex as it displays the last three entries related to each of eight fluids listed. Fluids that are not as commonly used do not have a three entry history, and instead are added below the list of more commonly used fluids.

Technically speaking, the TV display is created using jPanels, jFrames, and jTables. The display design follows a tree structure as shown in **Figure 11**. The parent element on which the rest of the display is built is a jFrame. Inside that jFrame is a jPanel, which is sized to fit a 1920 x 1080 HD television. This provides the most amount of room possible for Fluid, Drug, and Intervention data to be displayed. Inside the jPanel are three more jPanels, each containing a jLabel, and one or two jTables. The jLabels are used to display the name of the data to be displayed within the tables of each jPanel. For example, the jPanel containing the "Drugs" jLabel

populates the table in that jPanel with drug data as it is entered. The source code for the TV display is in file can be found in the Lifeboard software package, filepath "~/LifeboardGUI-Alex/src/view/StartScreen_v5.java". Data is retrieved from the Access Database using the file located in "~/LifeBoardGui-Alex/src/Controller/DatabaseRetrieval_test_v5.java".

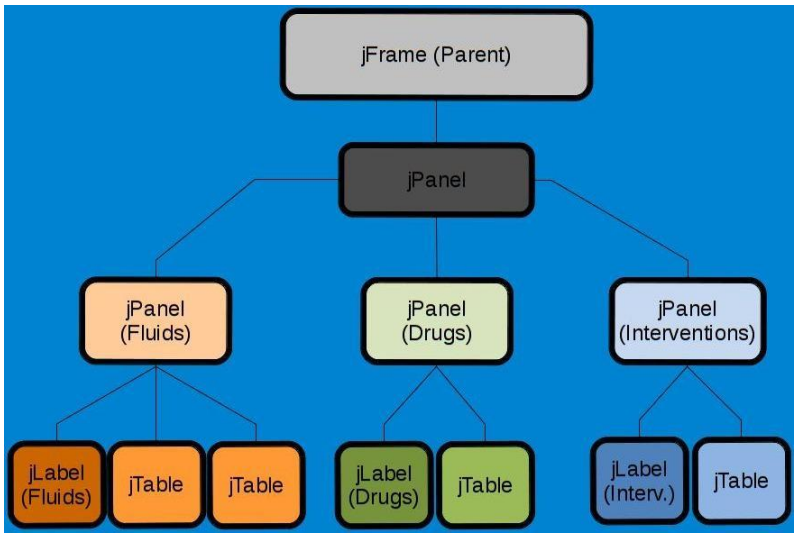


Figure 11: TV Display Software Structure

E. Abandoned Hardware Upgrades

In addition to the case, tablet, and display systems, a couple were considered for implementation but were ultimately abandoned. First, it was mentioned that wireless connectivity for the server and display screen was desired, but after researching these technologies and considering the ultimate placement of the server and display in a trauma bay, it was determined that maintaining a wired connection between these two would be cheaper and easier to do the permanence in both object locations in the room and the unreliability and expense of the currently available technology.

Another possibility was to integrate a prototype passive fluid monitoring system developed by Fluonics, a local medical device company. The device would measure fluid flow through tubes attached to the patient and wirelessly transmitted these values to the system's

server for further data capture. Due to manufacturing issues with Fluonics this implementation wasn't made available in time for integration and was shelved for a later iteration of the project.

V. Detail Design and Supporting Analysis

A. Mathematical or Computational Modeling and Analysis

As mentioned previously, the longer duration with initial contact the softer the force effectively is, (but too long and you hit amplification). After finding from the g-force graphs in **Figures 14-19** that t_impulse was 0.006s on average (max g-force found with testing the +/-250 accelerometer was 140g's from 3 feet), and given the momentum (mass*volume), F_i, or impulse force magnitude was found to be approximately 91lbs. To calculate if this much F_impulse is applied to these springs before completely max out the deflection, the equivalent spring constant could have been used as the softest spring constant dominates in series. Another way to think about it is that the materials will all see the same force so instead of doing a k_eq as seen in **Figure 32**, it was discovered from testing that the impulse force did not collapse the foam spring completely. If the foam completely collapsed, then that force would go to the plastic and then most all this force would be felt by the tablet.

Also as mentioned before, area is very important as the spring constant value of approximately 3000lbs/sqin depended on the area not being very large. When amplification is a result of that shock load, vibration under general forcing conditions can be described with a response spectrum of sinusoidal pulse. Suppose when you compute the spring constant, and you think about the mass and the stiffness of the tablet, you can compute the natural of that suspension, which is the foam. The natural period would be the inverse of the natural frequency. There's an amplification factor for shock load that's a function of the duration of pulse over the

natural period of the duration of pulse , once the pulse is long enough, there isn't much amplification and the reading is up at around 1.0 on **Figure 35**. This same figure also describes that the lower you make your natural frequency of system, the longer tou_n is and the longer tou_n is compared to length of pulse, the better off the impact absorption values.

The response displacement divided by the static deflection is the y-axis on this continued figure, and saying it will amplify the static deflection by 1.5 or 1.8 times possibly depending on the ratio of the two. My guess is you're duration of pulse is going to be so short you'll be in a decent region where it will not really amplify on the shock.

ISOLATION CALCULATIONS

Impulse Momentum

$w := 1.4$ $\quad m := \frac{1.4}{386}$ $\quad ti := 0.006$ Time duration of impulse from accelerometer data collected

$t := \sqrt{\frac{60}{386}}$ $\quad t = 0.394$

$v := 386 \cdot t$ $\quad v = 152.184$

$Fi := \frac{m \cdot v}{ti}$ $\quad Fi = 91.994$

Foam Interior Ultra-soft Sorbothane (Polyethylene)

$E := 36$ $\quad A := 2.32$ $\quad L := \frac{1}{8}$ $\quad D := .25$ This is an estimatation of the available deflection.

$kf := E \cdot \frac{A}{L}$ $\quad kf = 668.16$ $\quad Ff := kf \cdot D \cdot L$ $\quad Ff = 20.88$ Pounds of force at maximum deflection

UHMW Plastic

$E := 36$ $A := 1$ $L := \frac{1}{8}$ $D := .25$ This is an estimatation of the available deflection.

$kp := E \cdot \frac{A}{L}$ $kp = 288$ $Fp := kp \cdot D \cdot L$ $Fp = 9$ Pounds of force at maximum deflection

Maximum Acceleration Loading

$Ft := Ff + Fp$ $Ft = 29.88$

$At := \frac{Ft}{w}$ $At = 21.343$ g's of acceleration before spring system bottoms out

Isolation of System

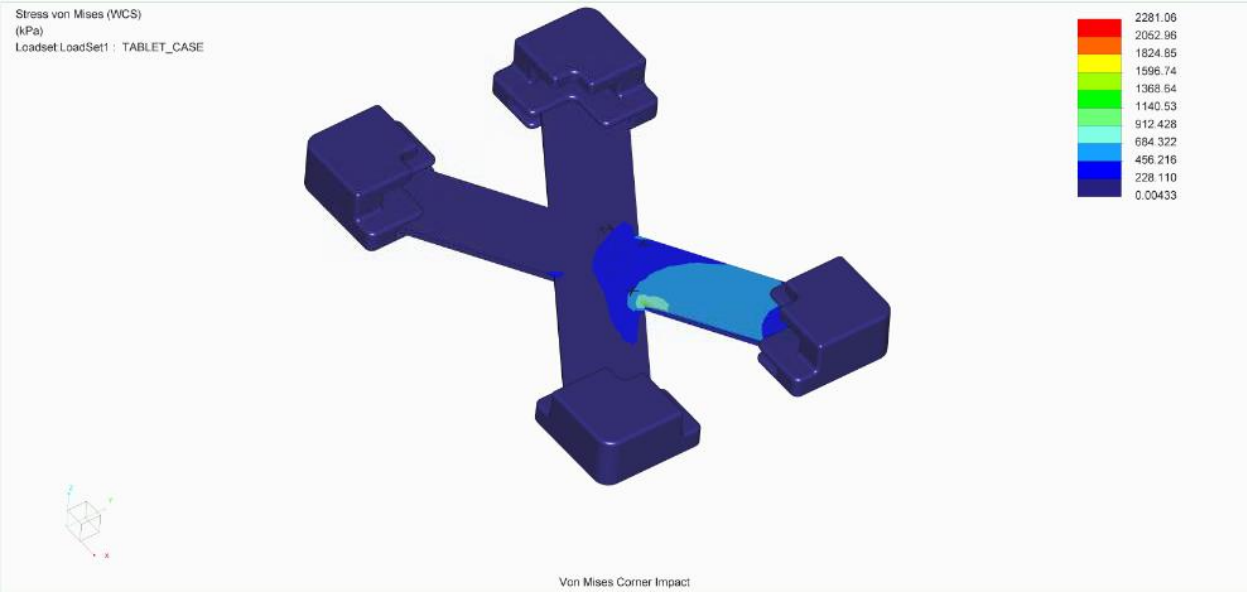
$ke := \left[\left(\frac{1}{kf}\right) + \left(\frac{1}{kp}\right)\right]^{-1}$ $ke = 201.253$ $fn := \frac{1}{2\pi} \cdot \sqrt{\frac{ke}{m \cdot 12}}$

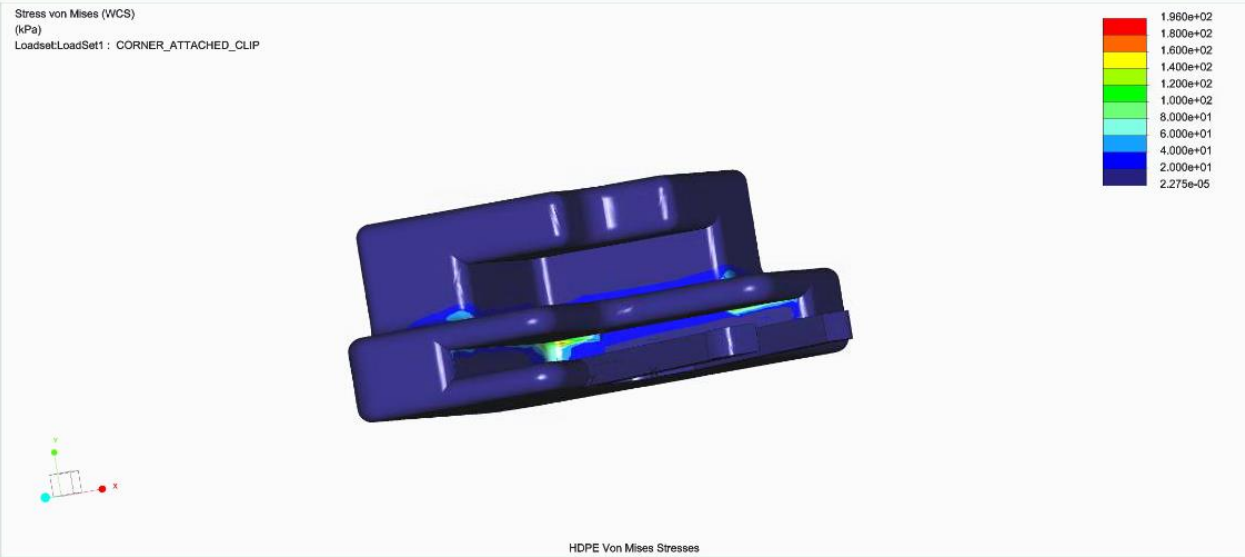
$T(ff, fn) := \left| \frac{1}{1 - \left(\frac{ff}{fn}\right)^2} \right|$

$T(77, 23.109) = 0.099$

Greater than 90% isolation is achieved for frequencies about 77 hz.

In order to have a second opinion on stresses, FEA models were originally created for the final prototype which explains why stresses are just a broad approximation and in different units.





B. Material Selection

Case materials were decided upon using multiple decision matrix-style charts. An initial list of materials for the case cross brace, corner pieces, and damping material was compiled based on material characteristics. The main criteria for cross brace material was tensile and shear strength. For the corner pieces, shear strength and impact strength were important. Damping material was decided upon mostly based on density and availability, however spring constants of the material should have been considered. The density of all materials was taken into account to reduce weight of the case. **Figure 36** were used to decide final materials for the case. These materials were decided to be 6k dry weave carbon fiber for the cross brace, UHMW for the corners, and Sorbothane for the impact padding.

Material	Density	Modulus of Elasticity	Yield Strength	Hardness	Impact Strength	Tensile Strength
Aluminum						
6061	0.098 lbs/in^3	10000 ksi	35-40 ksi	80-95 Brinell	n/a	35-45 ksi
Plastic						
UHMW	0.034 lbs/in^3	80ksi	n/a	d61-d77 (Shore)	16.8 ft-lbs/in – no break	5.8ksi
ABS	0.038 lbs/in^3	340ksi	n/a	R102-109 (Rockwell)	5.2-7.7 ft-lbs/in	6.5ksi
PLA	–	n/a	n/a	R84-115	10 in/lb	7.1ksi
Radel PPSU	–	n/a	n/a	R122	13 ft-lbs/in	10.1ksi
FEP	.078 lbs/in^3	n/a	n/a	R25	no break	3ksi
PFA	0.077 lbs/in^3	n/a	n/a	D60 (Shore)	no break	3.6-4 ksi
Composites						
Carbon Fiber (6k)	1.76Mg/m^3	228GPa	--	--	--	3.2GPa

Corner Padding Materials

Material	Density	Why should we use this for impact protection?
Sorbothane	1.36 g/cm^3	excellent design guide/material specs/adhesive recommendations
D3O ST	400-550 kg/m^3	material specs/intended use
FXI	--	not really designed for impact protection
ImpactGel	--	very little information, not clear if it can be ordered as sheet/sample

Corner Padding Materials Round 2

Material	Density	Why is this a good design decision?
Sorbothane	1.36 g/cm^3	excellent design guide/material specs/adhesive recommendations
D3O ST	400-550 kg/m^3	material specs/intended use

Figure 36: Material Decision Charts

C. Production Unit-Cost Analysis

After calculating the cost for each unit this project would be able to provide is of course an estimate with many depending factors. Two main factors would first include whether or not these products could be mass produced and secondly, comparing student labor hours versus profession-driven labor hours.

Case Production Unit- Cost [Excluding Labor Hours]		
Rockwest Composites	$ 52.99	Dry Woven Fabric - 3K - 2x2 Plain Weave - 204 GSM - 50" x 1 yard
Rockwest Composites	$ 42.99	West System - Base Epoxy Resin - 1 quart
Rockwest Composites	$ 21.99	West System - Fast Hardener - 0.44 pint
Alpha Plastics and Design	$ 52.52	UHMW1.5" X 12" X 12"
McMaster-Carr	$ 34.79	Ultra-Soft Polyurethane Strip, 1/8" Thick, 4" X 36", 50 Oo Durometer
Fibre Glast	$ 30.95	Parting Glass & PVA Release Film
Walmart	$ 55.34	Plaster Mold for Carbon Fiber, Xacto knife, Brush set, necessary tools
Project Software	$120.00	Microsoft Access
Total Spent	$ 411.57	
Max Possible Units	4.00	
Overestimated Production Unit-Cost	$ 102.89	

Table 4: Production Unit-Cost Analysis

VI. Final Evaluation

A. Manufacturing and Assembly

As mentioned previously there are three main parts of the final case design including the cross brace, the plastic corners, and the foam, while not forgetting about additional components such as the fasteners and hand strap.

For the carbon fiber manufacturing process, it was absolutely necessary for materials and chemicals to be ready prior to beginning for this fast paced and tricky procedure. First step is confirming a sufficient mold as the negative part for the fabric. For this project, a process of vacuum molding a heated polycarbonate plastic sheet was attempted multiple times before deeming the process a failure due to insufficient outcomes, see **Figure 24.** Instead of vacuum molding, a plaster mold process was attempted using an acrylic cross brace positive mold and successfully produced a perfect negative mold, see **Figure 26.** The release agent was generously brushed onto the dried negative plaster mold before the fiber fabric and epoxy resin chemicals were laid alternatively. A process necessity to include is confirming very accurate measurements of epoxy resin and fast hardener for maximum hardening, and only pouring small amounts of chemicals at a time into the small paper cups, too much mass of combination of these chemicals will surely create a chemical reaction and waste material, see **Figure 25**.

Case Part	Manufacturing Materials	Equipment
Cross Brace (Carbon Fiber)	Dry Woven Fabric - 3K - 2x2 Plain Weave - 204 GSM - 50" x 1 yard	Scale, scissors, sufficient ventilation, xacto knife, brush set, small paper cups and towels, vertical drilling
	Base Epoxy Resin - 1 quart, Fast Hardener - 0.44 pint, Parting Glass & PVA Release Film	
	Plaster Mold	Built wood frame for plaster mold, acrylic mold part
Exterior Plastic Corners	UHMW1.5" X 12" X 12"	Band Saw, vertical milling machine, grinder
Interior Foam Corners	Ultra-Soft Polyurethane Strip, 1/8" Thick, 4" X 36", 50 Oo Durometer	Scissors, caliper
Hand Strap	Store bought with velcro	Utilized holes drilled in carbon fiber
Fasteners	1/4" Al Binding Post with 3/16" Flat head slotted drive screws	Flat head
	Adhesive glue for foam to slit in UHMW plastic corners	-

Table 5: Manufacturing Information

Regarding the shape of each corners, it can be seen that there are 3 pieces, the top and bottom of the exterior corner and the foam insert, see manufacturing drawing in **Figures 20-23**. Initially each corner as to be as a whole, but within the manufacturing process soon realized there was not an end mill for the

vertical milling machine that was long enough for the cross brace slot. The top and bottom exterior parts are fastened with aluminum binding post and screws while the foam inserts are successfully fastened by adhesive glue as seen in **Figure 37**.

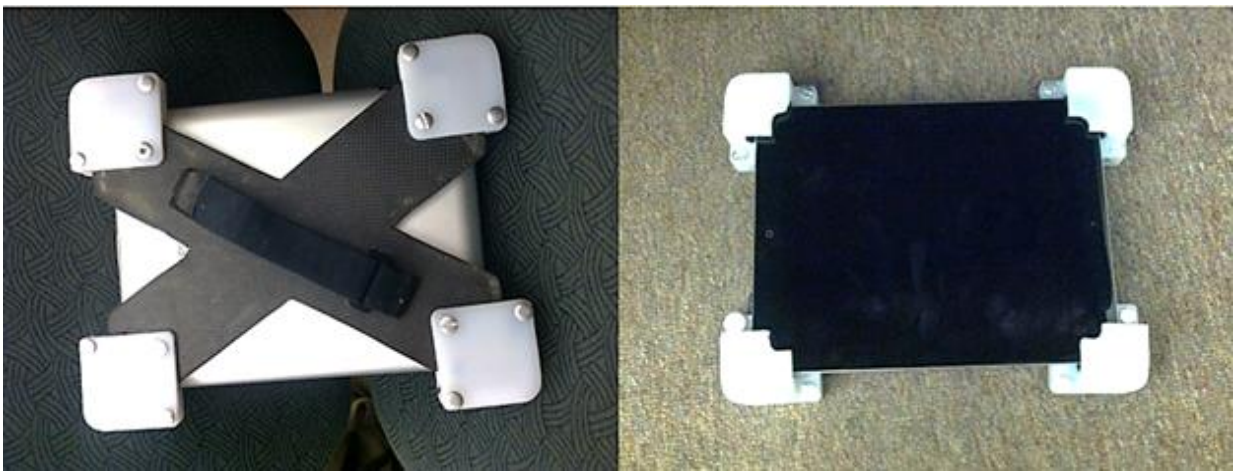


Figure 37: Manufactured Case: Front and Back Views

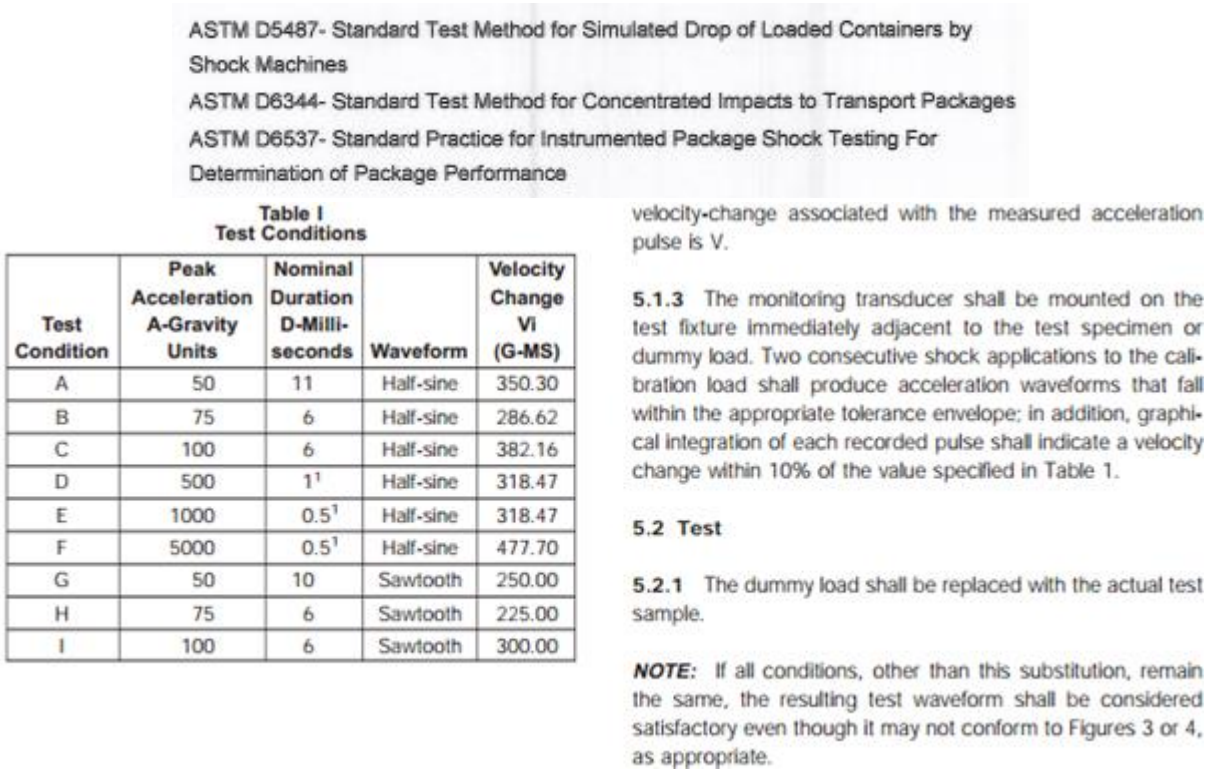
B. Testing and Refinement

The primary means of testing the interface software was through mock traumas and surveys conducted at Medical Center of the Rockies. Testing was completed throughout the year as a way of verifying new program features and to design flaws and weaknesses for improvement. Four times throughout the year the interface was brought to Medical Center of the Rockies and various medical staff used the system during various levels of mock trauma simulation. This varied from two people talking through the text transcript of a real-life trauma in the past to utilizing a full team of 10-20 medical professionals working through a trauma scenario in a trauma bay with a trauma dummy. In each of these four tests the user of the tablet was monitored and notes were taken on their usage, including suggestions for improvement, difficulties with completing tasks, and bugs discovered when testing. After these mock traumas

were completed discussions about interface improvements were held to further improve the design of the interfaces. See **Figure 12** for an example of the mock traumas.

In addition to these mock traumas, several members of the medical staff tested the tablet interface independently of these mock traumas to get a feel for the interface, explore it's capabilities, and provide feedback. After each of these interactions a survey was filled out to collect and organize feedback for the tablet interface, driving development further. For an example please see **Figure 13**.

For the case, please see **Figures 27-31** that shows the general testing process that was followed for drop testing the case. A general overview is to first find standards including the ones found in the following figures, but also MIL-STD-810G are extreme rugged tests but it helps as it is *Environmental Engineering Considerations and Laboratory Tests* with a section on shock.



ASTM D5487- Standard Test Method for Simulated Drop of Loaded Containers by Shock Machines

ASTM D6344- Standard Test Method for Concentrated Impacts to Transport Packages

ASTM D6537- Standard Practice for Instrumented Package Shock Testing For Determination of Package Performance

Table I
Test Conditions

Test Condition	Peak Acceleration A-Gravity Units	Nominal Duration D-Milli-seconds	Waveform	Velocity Change Vi (G-MS)
A	50	11	Half-sine	350.30
B	75	6	Half-sine	286.62
C	100	6	Half-sine	382.16
D	500	1[1]	Half-sine	318.47
E	1000	0.5[1]	Half-sine	318.47
F	5000	0.5[1]	Half-sine	477.70
G	50	10	Sawtooth	250.00
H	75	6	Sawtooth	225.00
I	100	6	Sawtooth	300.00

velocity-change associated with the measured acceleration pulse is V.

5.1.3 The monitoring transducer shall be mounted on the test fixture immediately adjacent to the test specimen or dummy load. Two consecutive shock applications to the calibration load shall produce acceleration waveforms that fall within the appropriate tolerance envelope; in addition, graphical integration of each recorded pulse shall indicate a velocity change within 10% of the value specified in Table 1.

5.2 Test

5.2.1 The dummy load shall be replaced with the actual test sample.

NOTE: If all conditions, other than this substitution, remain the same, the resulting test waveform shall be considered satisfactory even though it may not conform to Figures 3 or 4, as appropriate.

Figure 39: Standards for Drop Test Plan

After standards are found and considered as guides for the testing plan and references for max forces without damage, all testing equipment and data calculation plans should be sorted out. For this project a +/-250 accelerometer, semi-functional dummy tablets, appropriate ground material, and semi-complete equation plans were used. Drop testing started at 1 foot height and climbed to 3 feet by a foot at a time at four different tablet orientations. Averages of this data were calculated and can be found in the graphs in the appendix. All of this data was used and are further explained in the the Case Design Final Concept section of this report.

C. Project/Development Cost Summary

The budget income funding from the project sponsor in the amount of $4,500 was projected to be enough to successfully complete the project and proved to be true. After the funds were used for electronic hardware, software, raw materials, the remaining budget was so large we were able to provide additional products to the trauma room. The large products purchased for the Trauma Research Center will directly aid this project as well as any advancements of it. A summary of the budget can be found in the following table.

Material	Cost
Case Hardware and Electronics (Raw materials, Accelerometer, Dummy Tablet, etc.)	$ 800.00
Electronics (Laptop, Trauma Room TV Monitors, GoPro, etc.)	$ 3,570.00
Total Spent:	$ 4,370.00
Originally Received	*$ 4,500.00*
Remaining Budget:	**$ 130.00**

Table 6: All-Encompassing Project Budget

VII. Conclusions and Recommendations

The progress made on Lifeboard this year has made for a vast improvement in the system compared to the previous year's version. The user interfaces of the system have been dramatically upgraded to capture more information in a far quicker, easier, more efficient, more accurate way, the display system have been optimized to display only the most important of information for trauma personnel, the overall system architecture has been further updated and modernized, and the tablet case was designed and tested to fully protect the tablet.

There are many directions this project could move in during it's next design cycle. These include:

- The ability to add many more types of information to the tablet interface more interactively.
- Further development of the ACLS algorithms and burn reference material into active data entry formats.
- The design of a more efficient user interface.
- The integration of passive wireless data capture on medical equipment and on the patient to more accurately and easily collect data.
- A professional, final manufactured version of the tablet case with a clip corner quick release.

VIII. References

[1] Adil, Rauf (2012, Aug 2). The Usage of Tablets in the Healthcare Industry. Available: http://www.healthcareitnews.com/blog/usage-tablets-healthcare-industry

[2] (2011, February 28). Discussing the Future of Emergency Nursing [Online]. Available: http://mediccast.com/nursingnotes/2011/02/discussing-the-future-of-emergency-nursing/

[3] N/A (2013, Sept 13). Motion Computing Tablets. Available: http://www.motioncomputing.com/products/tablet_pc_c5.asp

[4] (2006, March 8). Customer White Paper: Tablet PCs in Health Care [Online]. Available: http://www.motioncomputing.com/resources/WhitePaper_HealthCare.pdf

[5] (2006-2013). ASTM International [Online]. Available: http://www.astm.org/Standards/category_index.html

[6] Iltifat Husain, Brett Einerson (2011 Jan 14). Top 15 Free Medical Apps for Healthcare Professionals. Available: http://www.imedicalapps.com/2011/01/top-free-android-medical-apps-healthcare- professionals/

[7] N/A (2012, November 2). Centers for Diesase Control and Prevention Body Measurements [Online]. Available: http://www.cdc.gov/nchs/fastats/bodymeas.htm

[8] N/A (2013). Nursing Statistics [Online]. Available: http://www.minoritynurse.com/minority-nursing-statistics

Appendix A: List of Tables

List of Tables

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Table 2	Design Constraints	11
Table 3	FMEA Analysis	15
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Appendix B: Figures

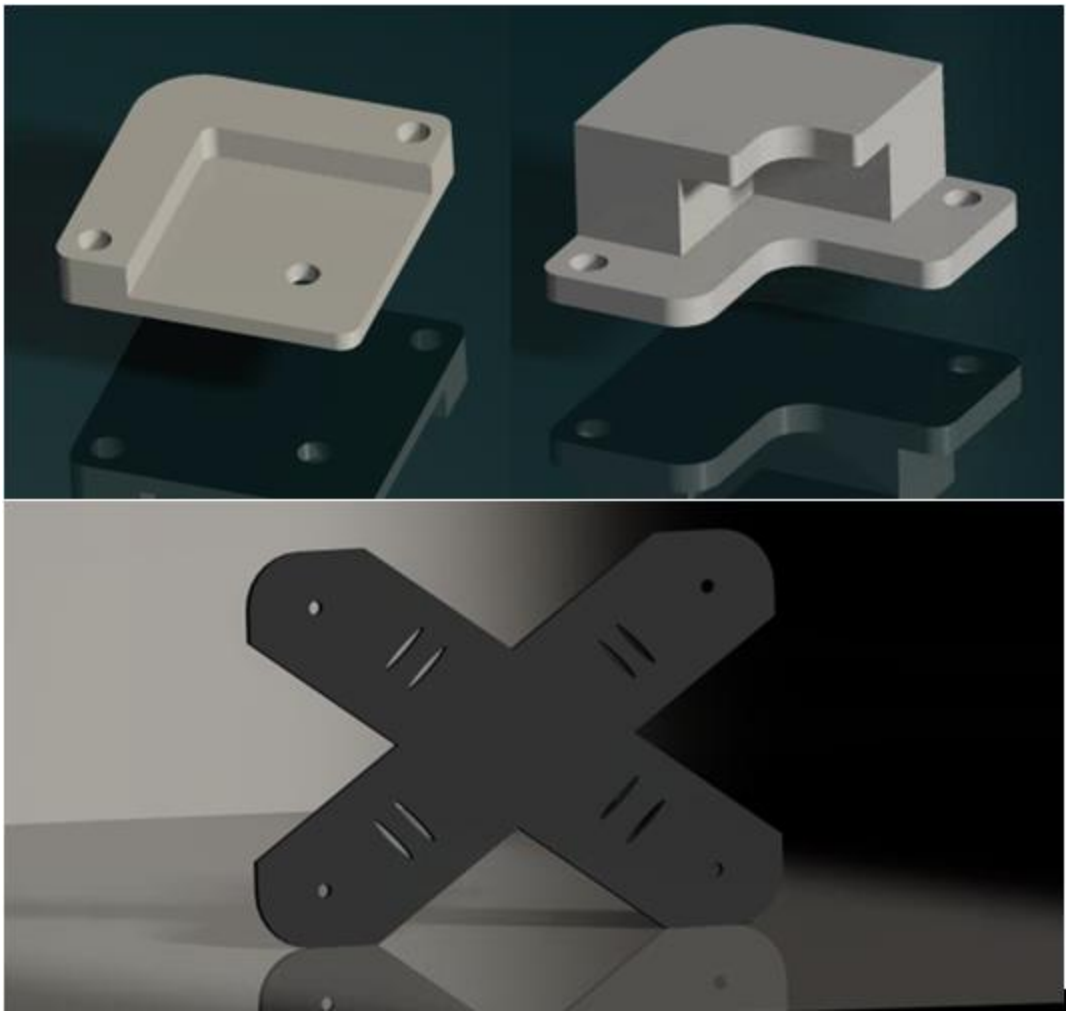


Figure 3: Individual Case Parts

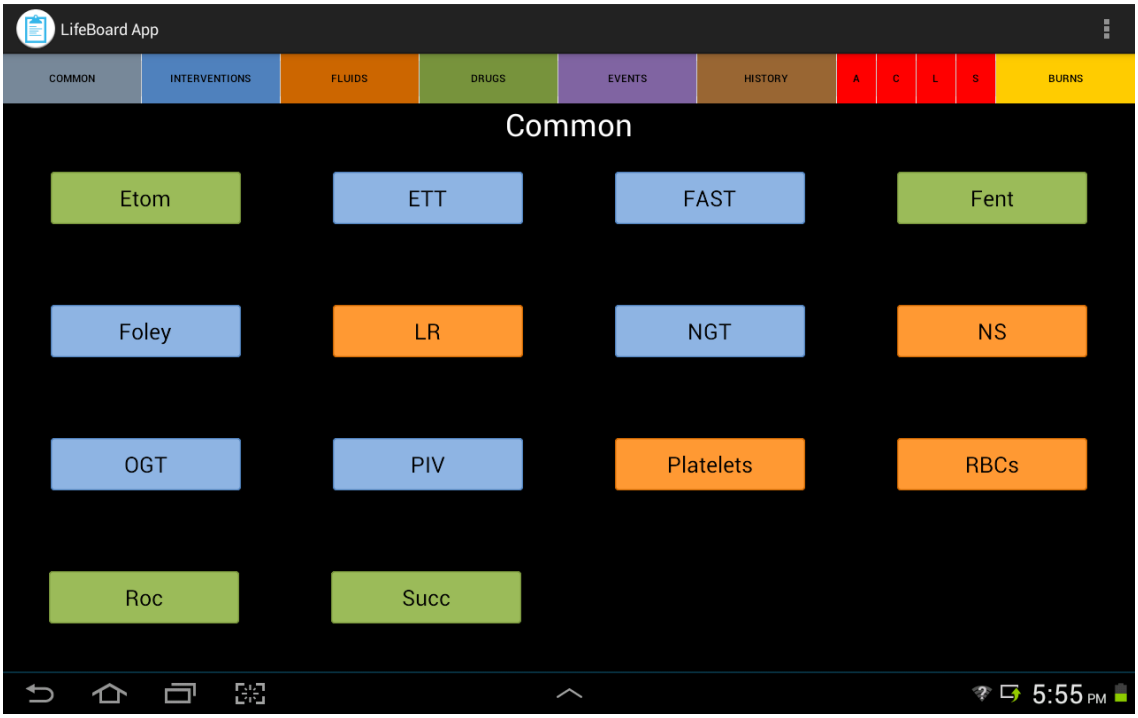


Figure 4: The Common Tab

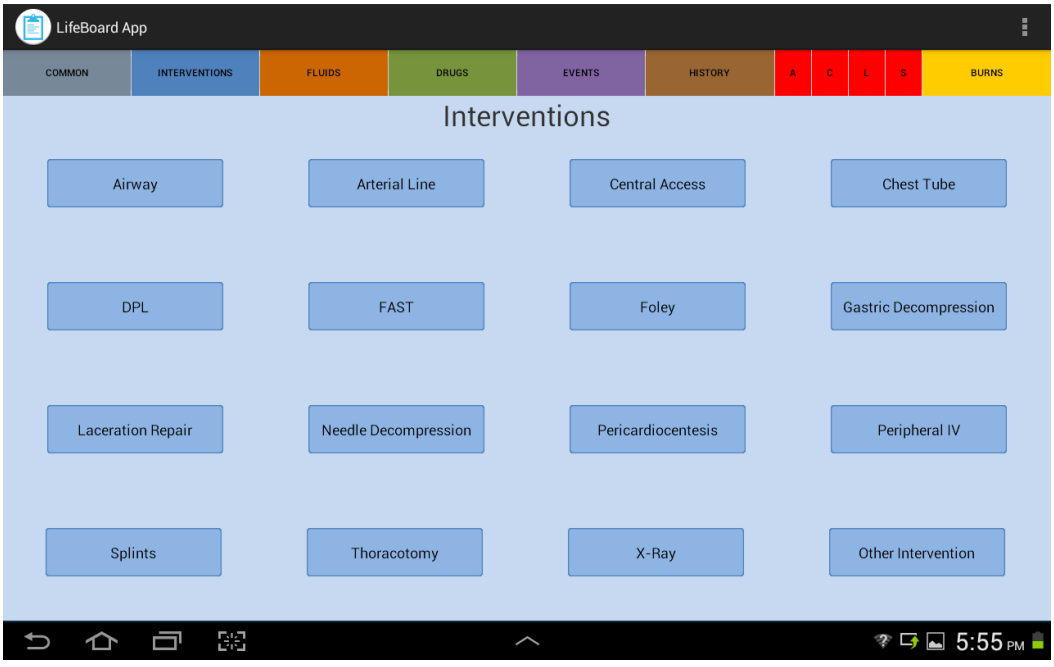


Figure 5: The Interventions Tab, similar to the Fluids Tab and the Drugs Tab

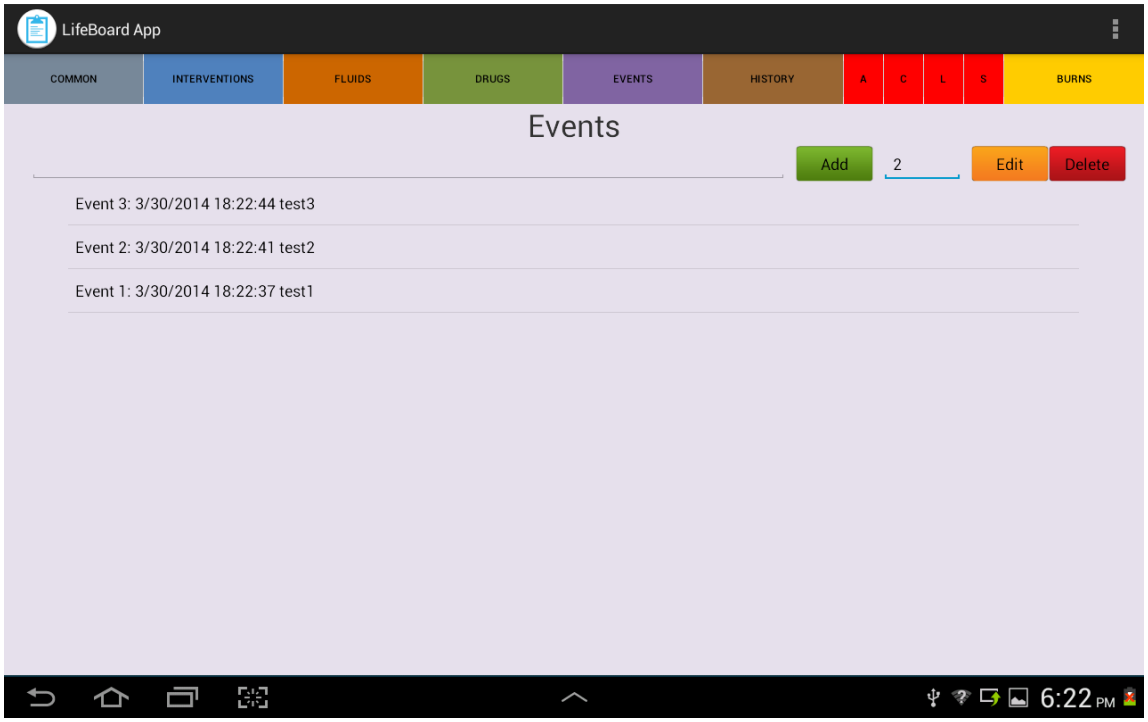


Figure 6: The Notes Tab, Including Add, Edit, and Delete function button

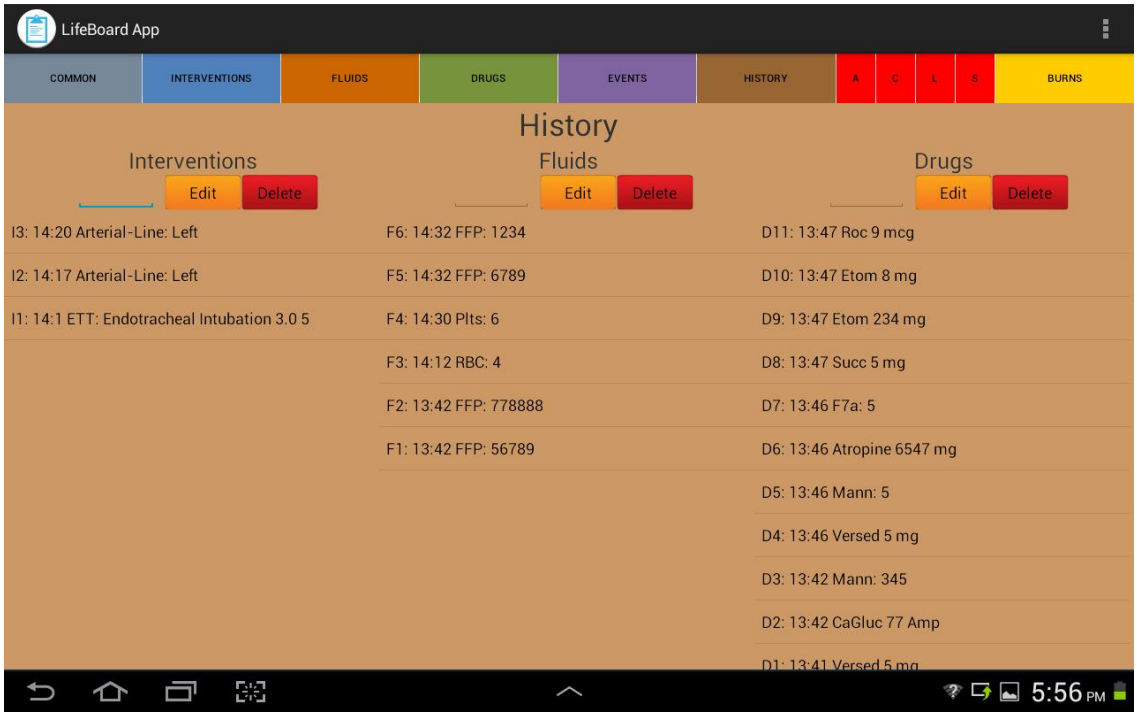


Figure 7: The History Tab, including all previously entered interventions, fluids, and drugs and edit/delete functionality for each section

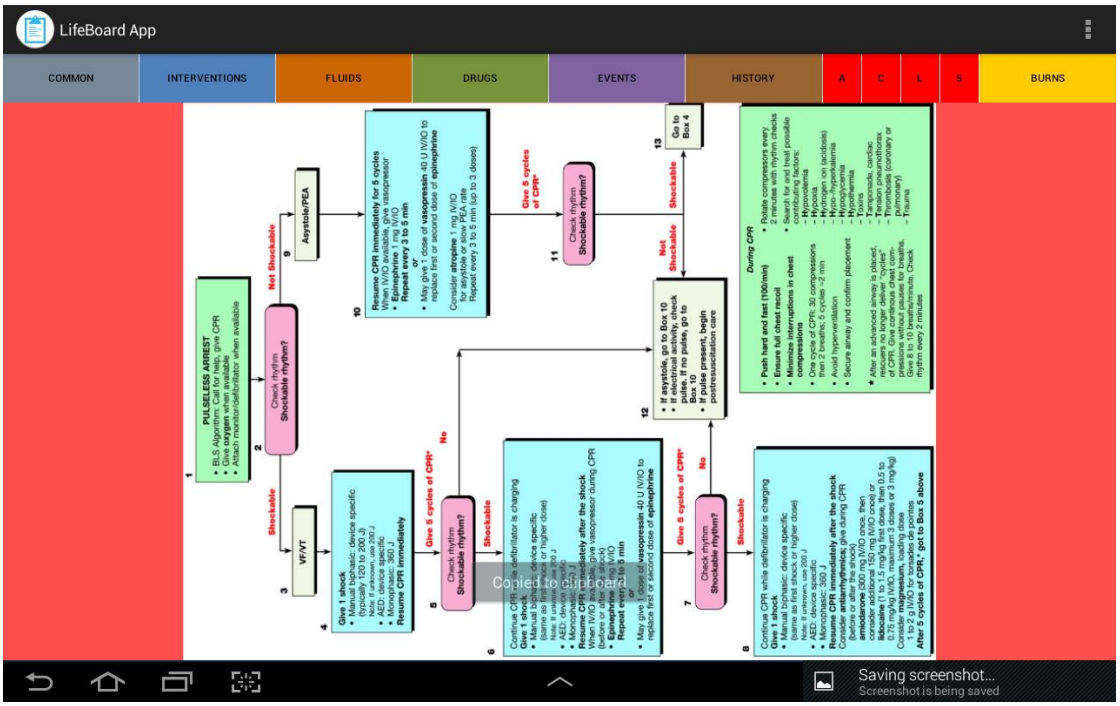


Figure 8: One of the Four ACLS Algorithm Reference Forms

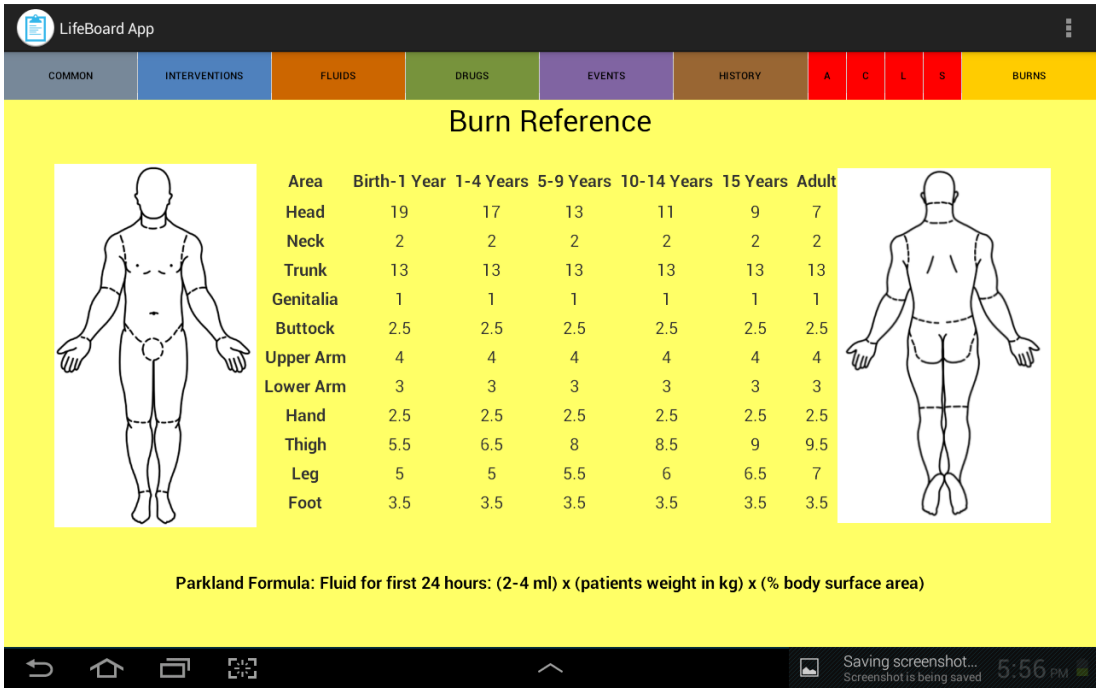

LifeBoard App
COMMON
INTERVENTIONS
FLUIDS
DRUGS
EVENTS
HISTORY
A
C
L
S
BURNS
Burn Reference
Area | Birth-1 Year | 1-4 Years | 5-9 Years | 10-14 Years | 15 Years | Adult
Head | 19 | 17 | 13 | 11 | 9 | 7
Neck | 2 | 2 | 2 | 2 | 2 | 2
Trunk | 13 | 13 | 13 | 13 | 13 | 13
Genitalia | 1 | 1 | 1 | 1 | 1 | 1
Buttock | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5
Upper Arm | 4 | 4 | 4 | 4 | 4 | 4
Lower Arm | 3 | 3 | 3 | 3 | 3 | 3
Hand | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5
Thigh | 5.5 | 6.5 | 8 | 8.5 | 9 | 9.5
Leg | 5 | 5 | 5.5 | 6 | 6.5 | 7
Foot | 3.5 | 3.5 | 3.5 | 3.5 | 3.5 | 3.5
Parkland Formula: Fluid for first 24 hours: (2-4 ml) x (patients weight in kg) x (% body surface area)
Saving screenshot...
Screenshot is being saved
5:56 PM

Figure 9: The Burn Reference Tab

Figure 10: Lifeboard TV Display

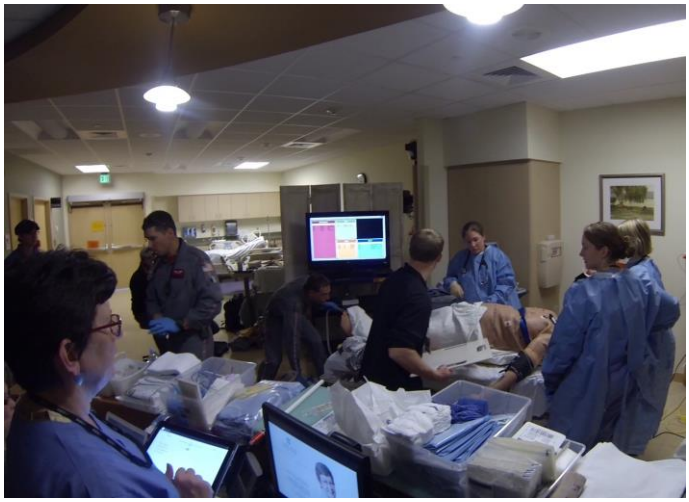
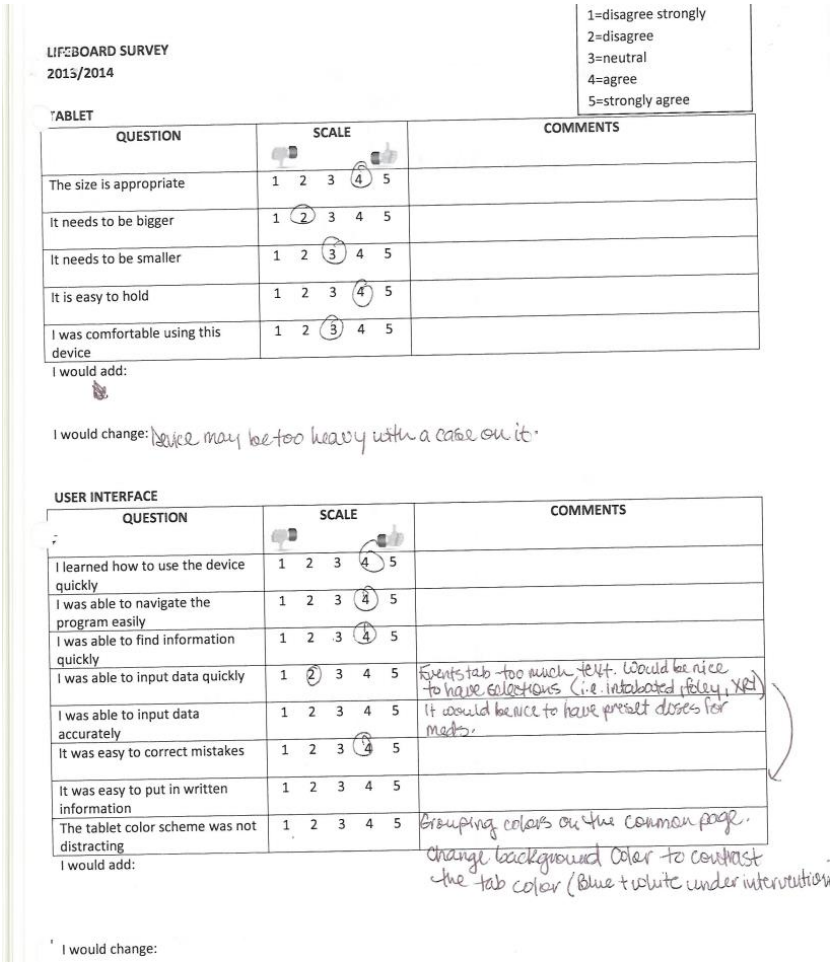


Figure 12: Mock Trauma with Trauma Dummy and Full Team Using Lifeboard



LIFEBOARD SURVEY
2015/2014

1=disagree strongly
2=disagree
3=neutral
4=agree
5=strongly agree

TABLET

QUESTION	SCALE	COMMENTS
The size is appropriate	1 2 3 (4) 5	
It needs to be bigger	1 (2) 3 4 5	
It needs to be smaller	1 2 (3) 4 5	
It is easy to hold	1 2 3 (4) 5	
I was comfortable using this device	1 2 (3) 4 5	

I would add:

I would change: device may be too heavy with a case on it.

USER INTERFACE

QUESTION	SCALE	COMMENTS
I learned how to use the device quickly	1 2 3 (4) 5	
I was able to navigate the program easily	1 2 3 (4) 5	
I was able to find information quickly	1 2 3 (4) 5	
I was able to input data quickly	1 (2) 3 4 5	Events tab too much text. Would be nice to have selections (i.e. intoxicated, Foley, XRT)
I was able to input data accurately	1 2 3 4 5	It would be nice to have preset doses for meds.
It was easy to correct mistakes	1 2 3 (4) 5	
It was easy to put in written information	1 2 3 4 5	
The tablet color scheme was not distracting	1 2 3 4 5	Grouping colors on the common page. Change background color to contrast the tab color (Blue + white under interventions)

I would add:

I would change:

Figure 13: Example of a Lifeboard Tablet Survey

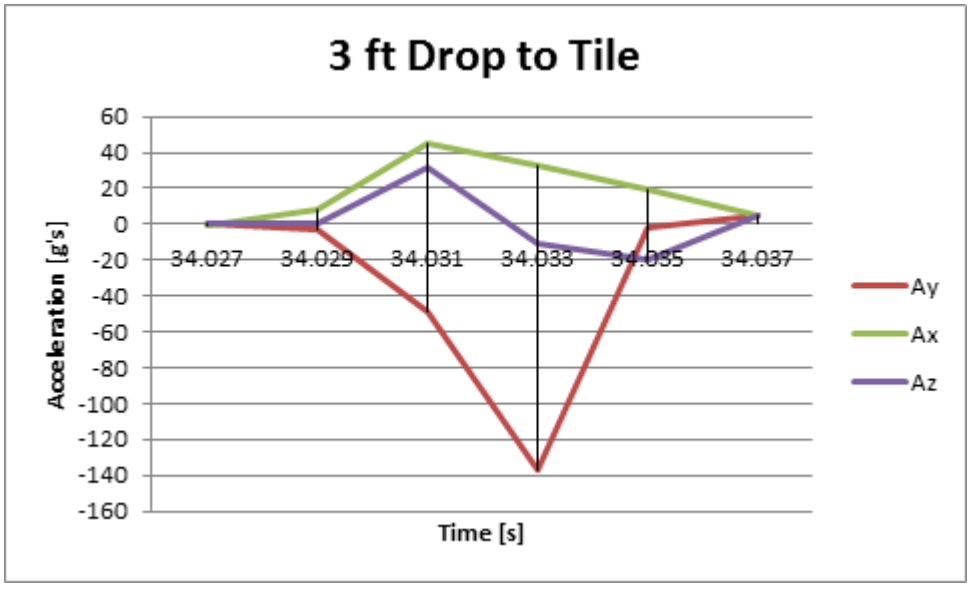


Figure 14: Three Foot Drop onto Tile

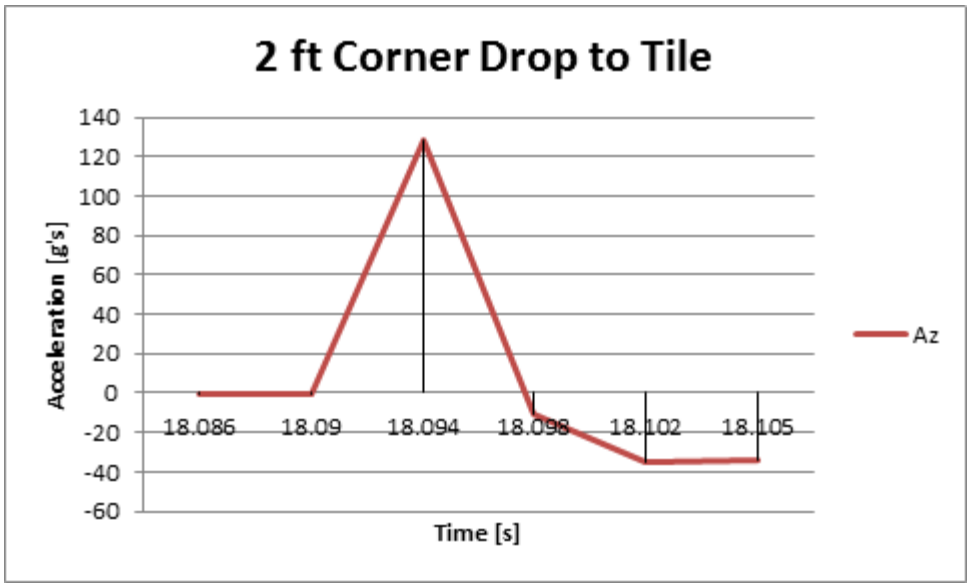


Figure 15: Two Foot Corner Drop onto Tile

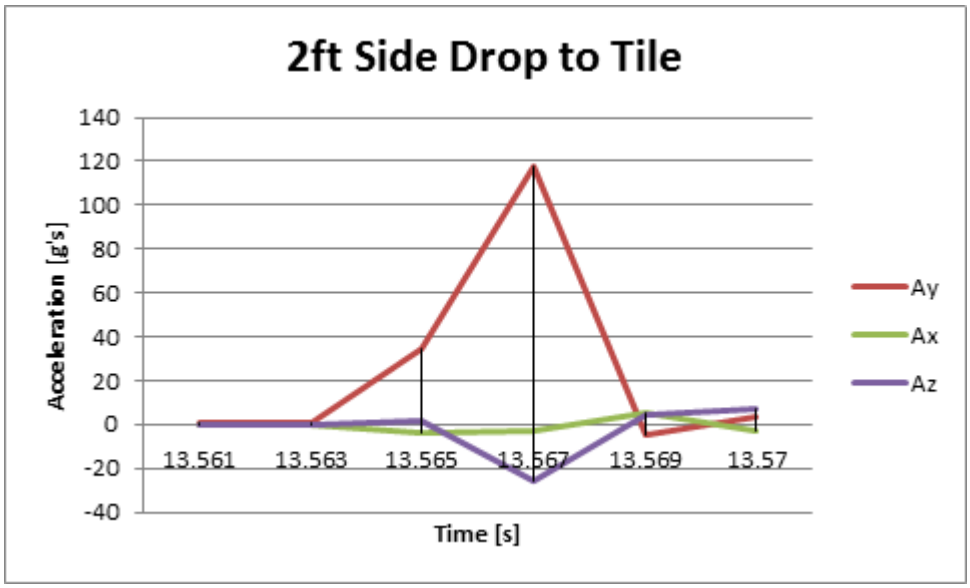


Figure 16: Two Feel Side Drop onto Tile

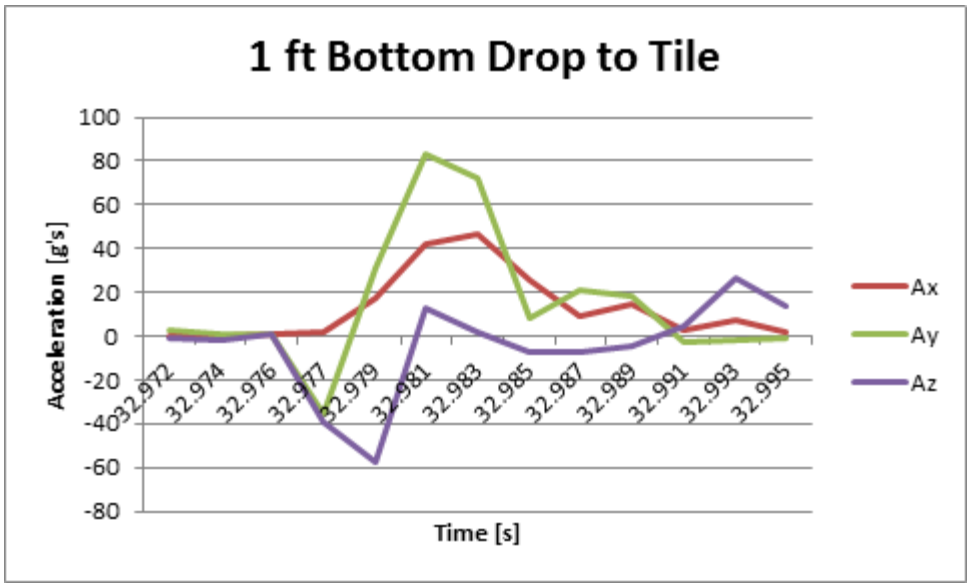


Figure 17: One Foot Bottom Drop onto Tile

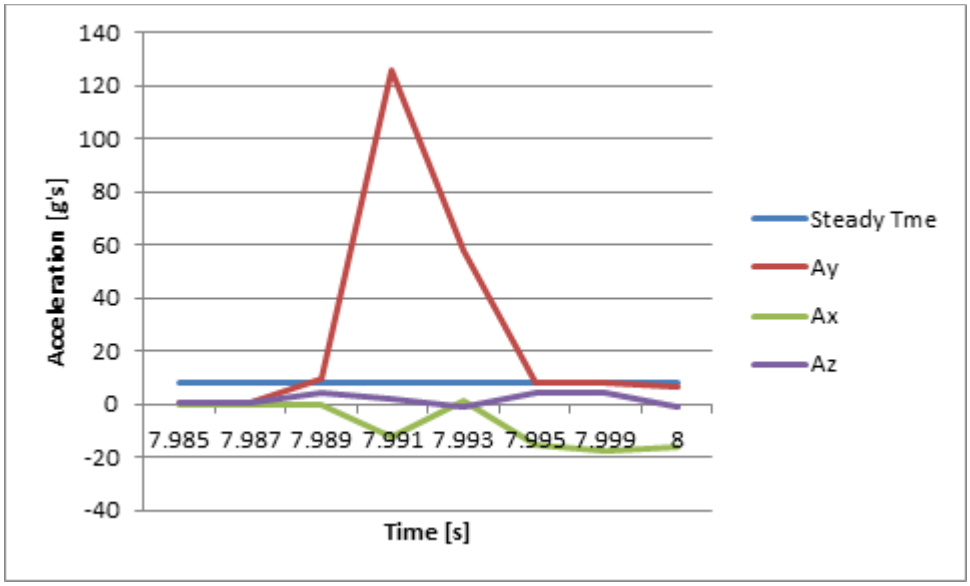


Figure 18

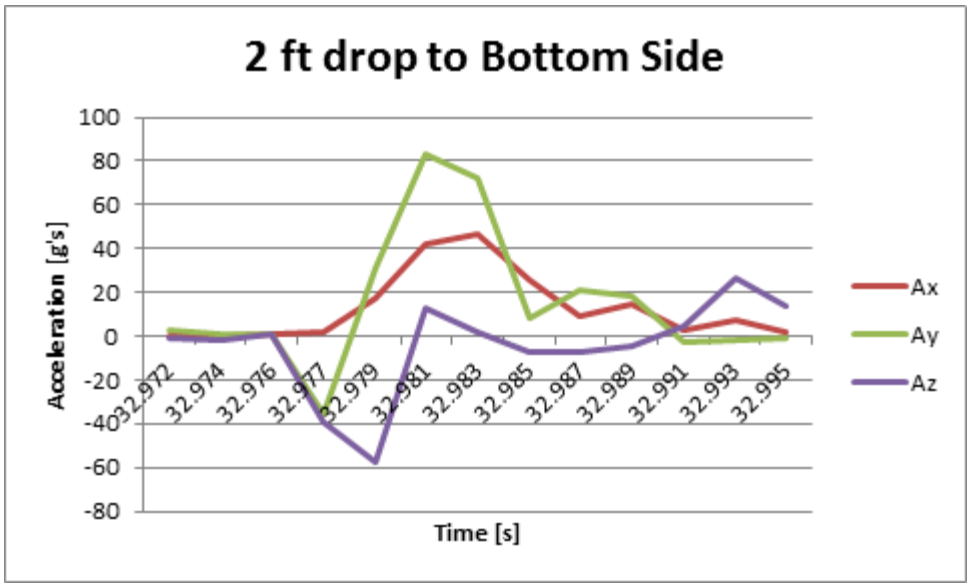


Figure 19: Two Foot Drop into Bottom Side

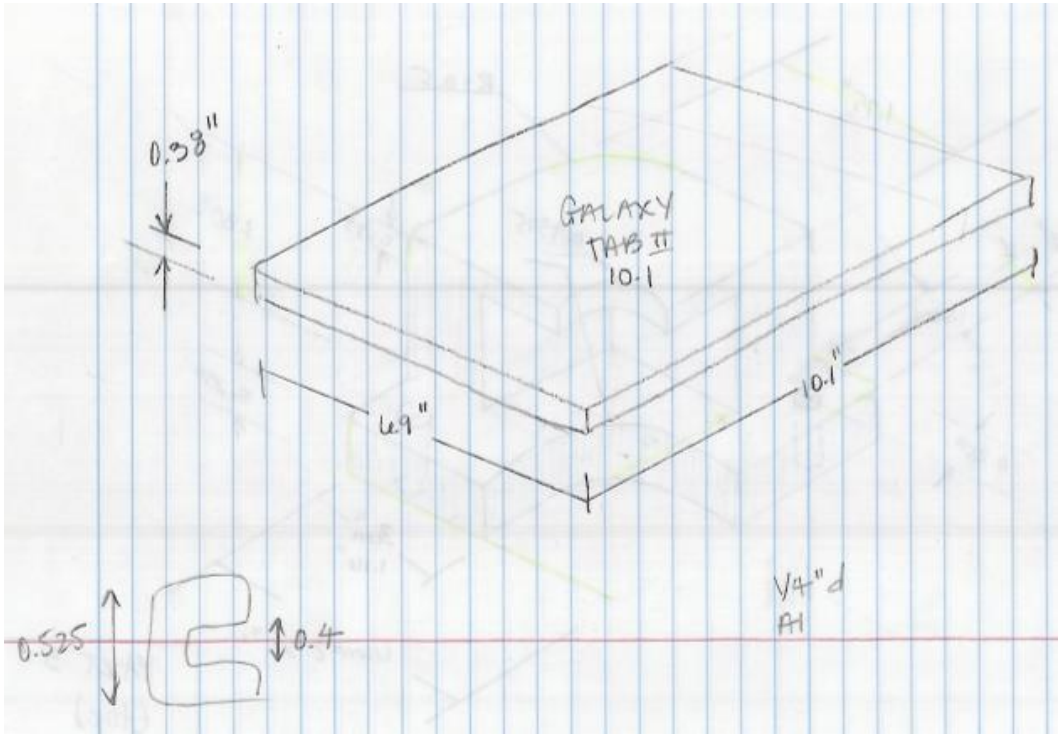


Figure 20: Tablet and Foam Drawing

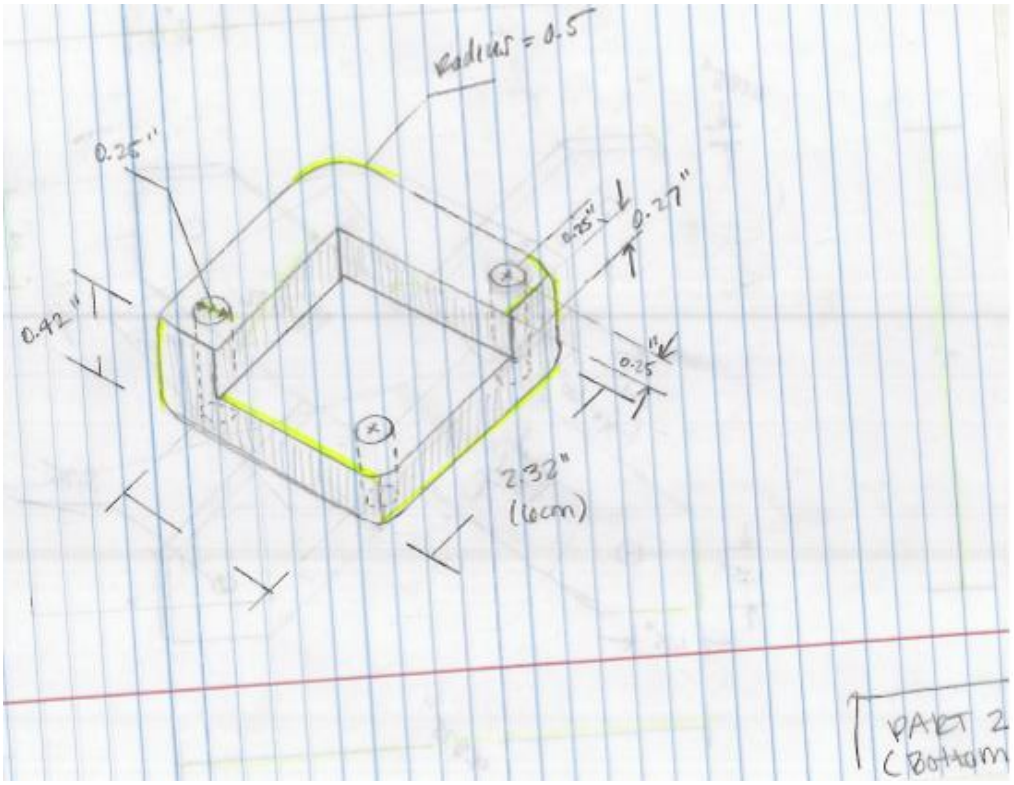


Figure 21: Case Corner Drawing - Bottom

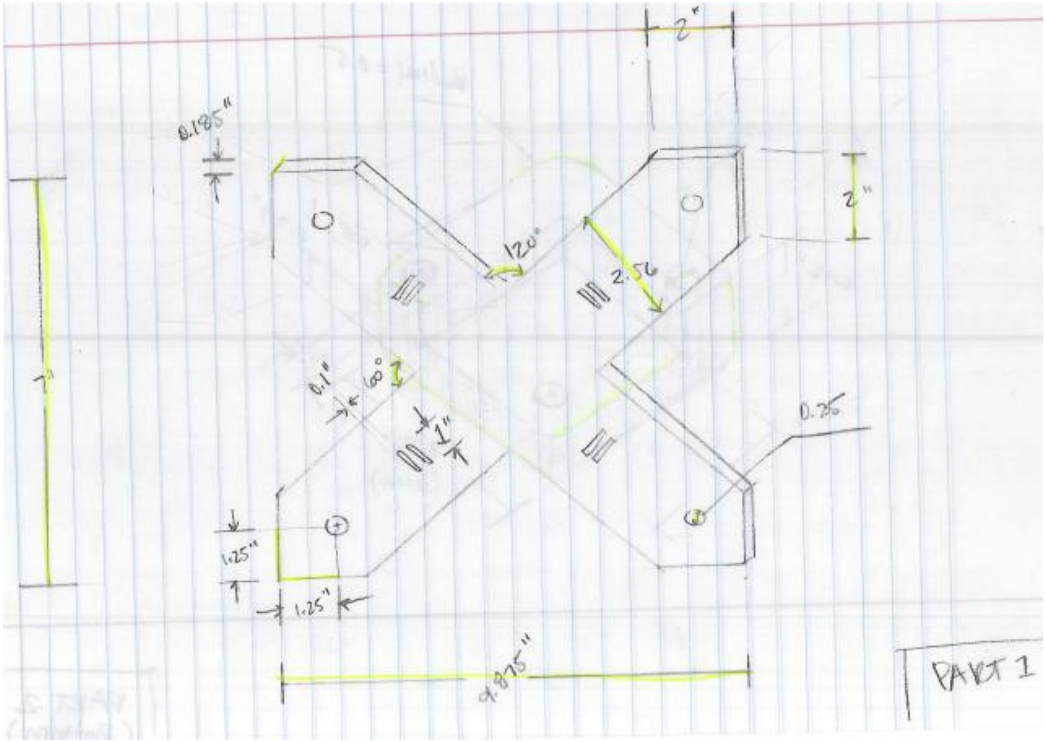


Figure 22: Case Cross Brace Drawing

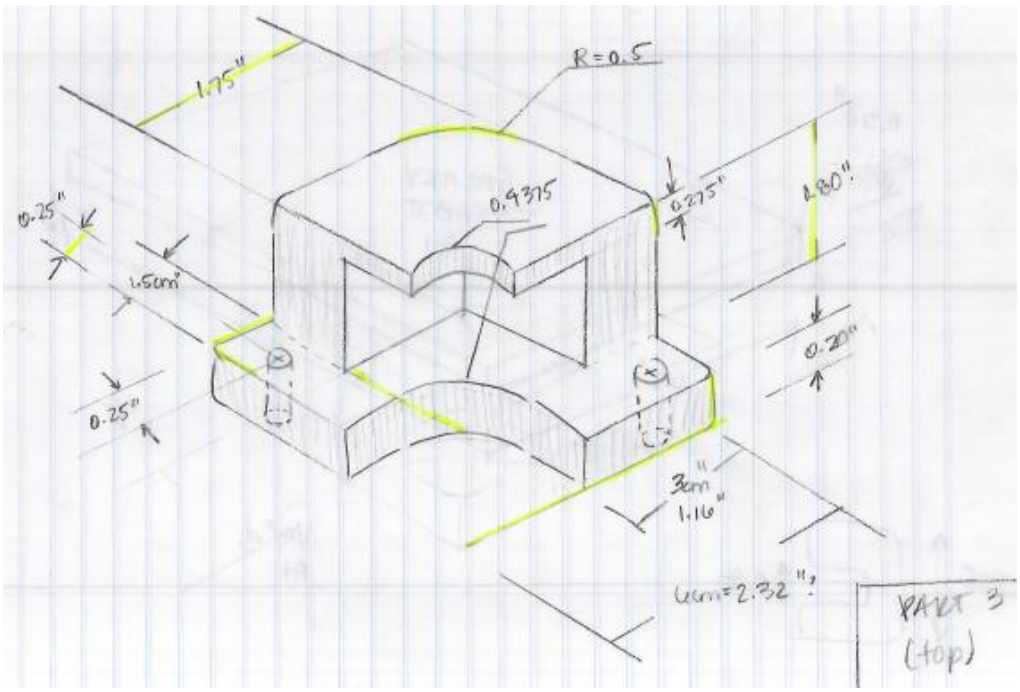


Figure 23: Case Corner Drawing - Top

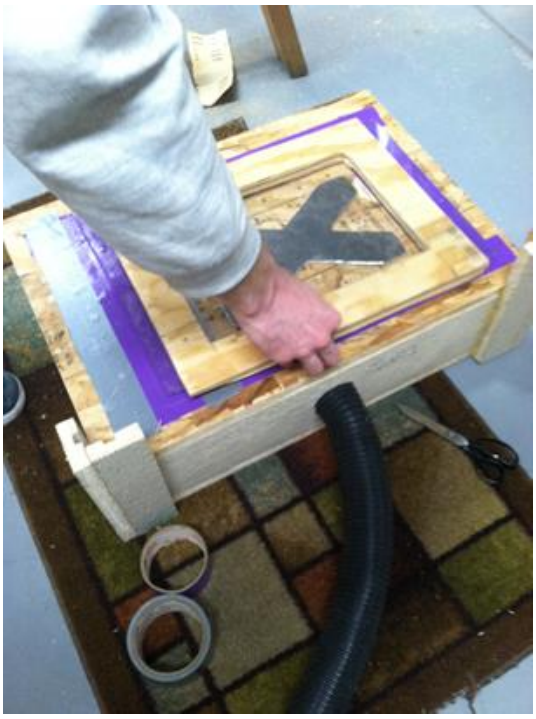


Figure 24: Vacuum Molding

Figure 25: Epoxy Resin and Hardener Chemical Reaction

Figure 26: Carbon Fiber Manufacturing

CASE DROP TEST PLAN

I. Introduction
   a. Purpose
      i. The Lifeboard team creating a sufficient case for the Samsung Galaxy Tablet requires the successful determination and execution of a proper final case design. For appropriate tablet protection, the case testing system involves the analysis of gathered quantitative and qualitative experimental data of multiple trials to find case impact absorption ability.
   b. Summary
      i. Scope
         1. The successful completion of FEA model, drop, ergonomics, and material cohesion testing predict expected results of valuable stress inducing force dispersion and overall project objective satisfaction.
      ii. Objectives
         1. This specific testing plan is for drop testing the case. The most pertinent objectives for drop testing are for the case weight to be <=5 lbs and to find the most optimized design for impact accommodation.

II. Testing Schedule

Test both prototypes	20 days	Mon 3/3/14	Fri 3/28/14	Funk,Garcia
Gather case test data and analyze	10 days	Mon 3/3/14	Fri 3/14/14	Funk,Garcia
Make nec updates and gather test data	10 days	Mon 3/17/14	Fri 3/28/14	Funk,Garcia
Updates and Report	12 days	Fri 3/28/14	Mon 4/14/14	Garcia

Figure 27: Drop Test Plan Doc 1

III. Required resources (dedicated/allocated to testing)
   a. Hardware
      i. Dummy tablets
         1. Defective Samsung Galaxy II 10.1 Tablet
         2. Wood for testing the case before the actual dummy
      ii. Accelerometers: multiple 'USB Impact Accelerometer Data Loggers'
         1. 250g +/-50g range, three axis accelerometer data recorder; continuously stored to a 2GByte microSD card. Plug the device into any USB host to access the text based .csv data files
      iii. Corner, cross brace, and padding material
         1. See attached excel sheet
      iv. Reliably accessible computer for data storage and computational purposes
   b. Software
      i. CREO Parametric for previous FEA testing
      ii. Mathcad
      iii. Microsoft Excel

   c. Team
      i. Funk/Garcia: coordinates test plan, determines material with design, determines accelerometer, orders and manufactures materials and hardware, operates test procedures, records and analyzes results
   d. Facility
      i. Medical Center of the Rockies for its medical professional opinions and tile floors for drop/ergonomics testing
      ii. Colorado State University for dependable computer and installed software to properly execute FEA modeling and record and analyze results

Figure 28: Drop Test Plan Doc 2

IV. Features and functions to test

a. Configuration Building

i. Use previous material cohesion testing to manufacture case prototype versions A and B.

ii. Install wood or tablet dummy tablet.

iii. Fix/mount accelerometer to case and balance out case with equivalent weight on opposite side to not through off center of gravity.

iv. Drop wood/tablet dummy tablet, case, and accelerometer fixture and record provided quantitative and qualitative data.

v. Use Mathcad and excel to analyze necessary data for calculations to finding how well the case absorbs impact.

b. Tested Aspects

i. Testing is conducted to analyze the level of success of a certain combination of the case corner pieces and the cross brace; test which design handles the drop forces most efficiently

c. Test entry criteria

Test Entry Criteria
Weight of corner pieces, cross brace, and cohesive material combined
Weight of wood, dummy tablet, tablet
Material Properties (modulus of elasticity, density, flexural modulus, tensile modulus, tensile strength, elongation at break) of each of these 3 case elements
Dimensions of each of the 3 case elements
Orientation of specimen to be drop tested
Height of drop
Location of Accelerometer

Figure 29: Drop Test Plan Doc 3

DROP TESTING

Data Collection and Input

*Captured at *512 Hz Freq for all*

Drop	Case Prototype	Height [in]	Test Orientatio
1	A	24	1
5	B	12	1
6		12	2
7		12	3
8		12	4
13	B	24	1
14		24	2
15		24	3
16		24	4
21	B	36	1
22		36	2
23		36	3
24		36	4

Figure 30: Drop Test Plan Doc 4

Configuration Description

Test Orientation	Description	Accelerometer Location (Always closest to impact location)
1	Front/Rear Face	Opposite face (flat on top)
2	Right/Left Side	Outside of UHMW Plastic of one corner
3	Top/Bottom Side	Outside of UHMW Plastic of one corner
4	Corner	Outer corner of UHMW Plastic

Case Prototype Version

Version	Corner Material	Cross Brace Material	Padding Material
A (wood)	UHMW Plastic	Carbon Fiber	Sorbothane
B	UHMW Plastic	Carbon Fiber	Sorbothane
AA (wood) -NA	UHMW Plastic	Aluminum	Sorbothane
BB -NA	UHMW Plastic	Aluminum	Sorbothane

Figure 31: Drop Test Plan Doc 5

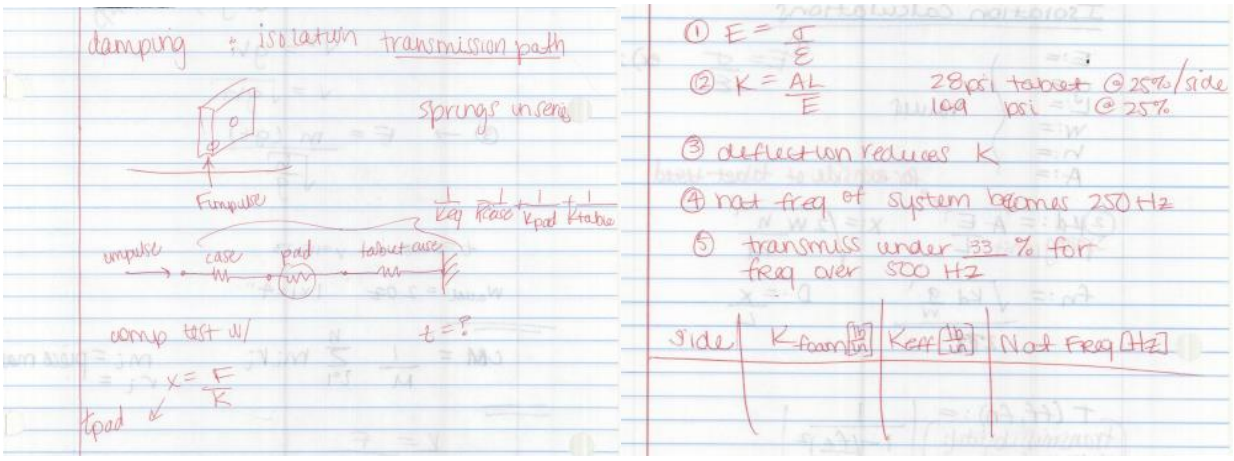


Figure 32: Case Analysis 1

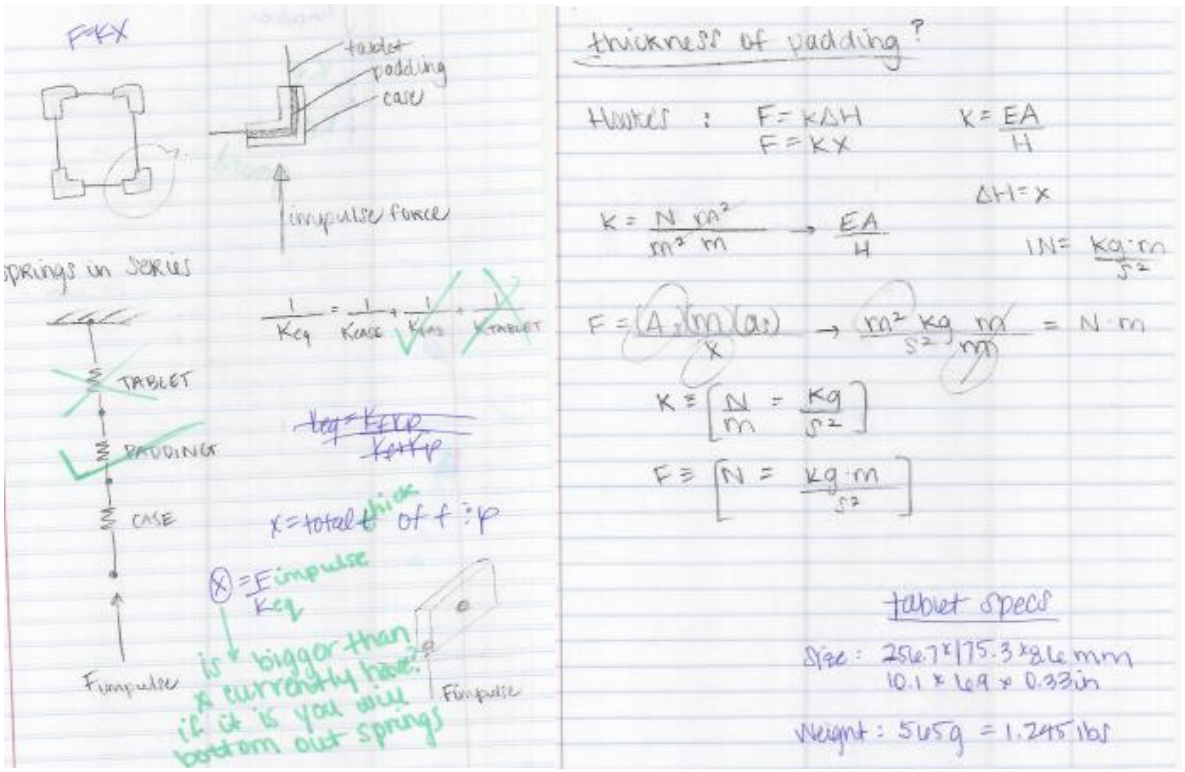


Figure 33: Case Analysis 2

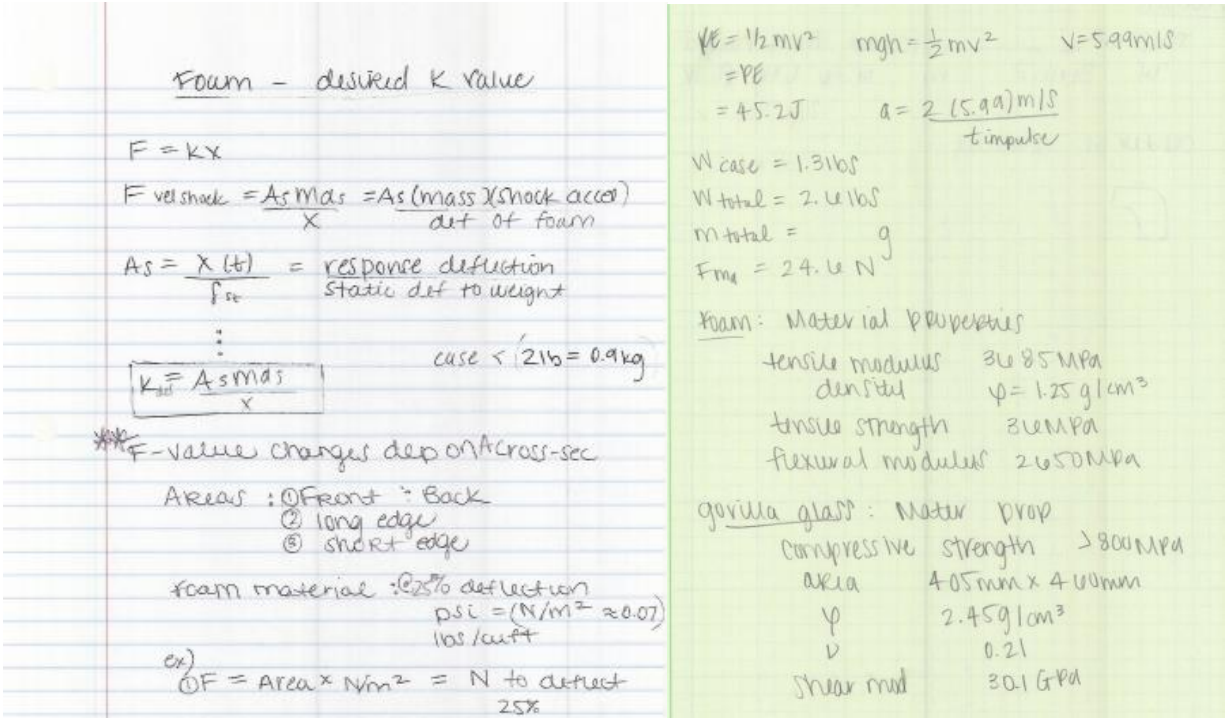

Foam - desired K value
F = kx
F vel shock = As mas / X = As (mass)(shock accel) / def of foam
As = X (ft) / f st = response deflection / static def to weight
case < 2lb = 0.9kg
F-value changes dep on A cross-sec
Areas : ① Front : Back
② long edge
③ short edge
foam material : @25% deflection
psi = (N/m² ≈ 0.07)
lbs/cuft
ex)
① F = Area x N/m² = N to deflect 25%
PE = ½mv² mgh = ½mv² v = 5.99m/s
= PE
= 45.2J a = 2(5.99)m/s / t impulse
W case = 1.3lbs
W total = 2.6lbs
m total = g
F max = 24.6 N
foam : Material properties
tensile modulus 3685 MPa
density ρ = 1.25 g/cm³
tensile strength 8 MPa
flexural modulus 2650 MPa
gorilla glass : Mater prop
Compressive strength > 800 MPa
area 405 mm x 440 mm
ρ 2.45 g/cm³
ν 0.21
Shear mod 30.1 GPa

Figure 34: Case Analysis 3

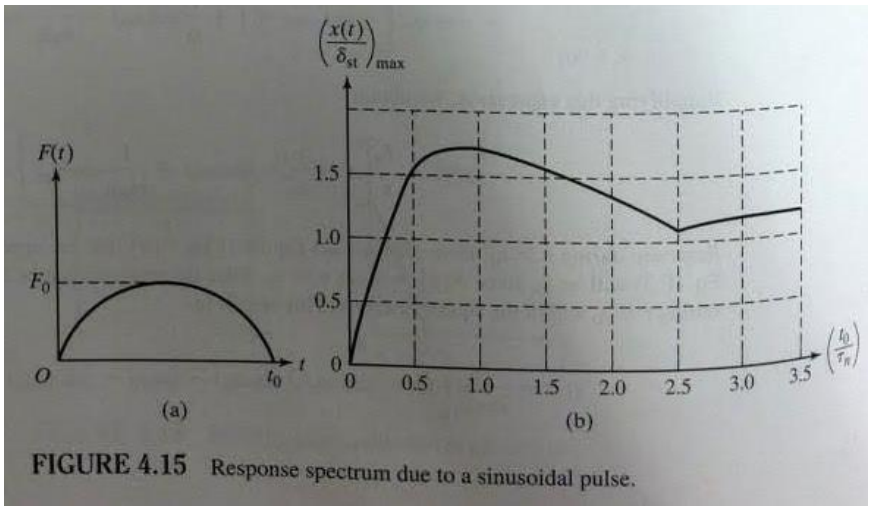


Figure 35: Amplification

Lifeboard User Manual/Information for Developers

I. Software

All software is stored and organized in Eclipse with the Android SDK Plugin installed. This is pinned to the taskbar and can be found in Users/Trauma Research/Android Eclipse ADT/eclipse/eclipse.exe. There are three project libraries of software that run on Eclipse to develop and run the system - JavaServer, Lifeboard_App, and LifeBoardDisplayGui.

JavaServer

JavaServer manages the communication between the Android tablet application and the database stored on the server computer. The main java file for this project is called TCPServer.java and it runs the communication interface. Before running this program on the terminal inside Eclipse, a wireless network needs to be created on the server. This requires a wireless card installed that can generate it's own network (most modern wireless cards can). Open a command line terminal in Windows and run the following command (usually this needs to be run as administrator):

netsh wlan set hostednetwork mode=allow ssid=LifeBoardNetwork key=12345678

A network should be created successfully. Change the ssid and key to any of your choosing. After this is created run the following command to start the wireless network. The network can be closed by replacing 'start' with 'stop' after it has been started:

netsh wlan start hostednetwork

Once this is done take the tablet and connect it to the network like you would with a normal wireless network. Now run the TCPServer.java program in Eclipse and the database will be cleared and prepared for collecting data from the tablet. Start entering data into the tablet and you should see it entered into the console on the server. The database file that is collecting data is called lyfeboard.accdb and can be opened with Microsoft Access.

LifeBoard_App

This project is the Lifeboard Application itself. There is a full set of java files and a full set of corresponding xml files. The application can either be run directly on the tablet or using a virtual machine setup in Eclipse. When running the virtual machine using port 5554 usually does not work, so create two instances of the virtual machine and use the one at port 5556. It will take a couple minutes to load. For MainActivity.java setup the run configurations for this file and run

the file in Eclipse to either load the latest version of the application onto the virtual machine or onto the tablet connected via USB or both.
MainActivity.java and sliding.xml are the two main files for the application. MainActivity.java manages all of the programmable aspects of the application such as button initialization, what buttons do, data writing, etc. sliding.xml manages the visual interface of the application. Changes will need to be made on these two files simultaneously to correctly change the application. All of the dialogs have their own Java and XML files. Refer to EditArterialDialog.java for a fully commented version.

LifeBoardDisplayGui

This project hosts the display application for the system. Editing and developing the display can be carried out in NetBeans. Once TCPServer.java is running correctly with the tablet launch Start_ScreenX.java and the display application will run and pull information from the database into the display. There are multiple versions of this that track the process of development. All development in this system was completed by Alex Funk.

Additional Software Installed On Computer

Microsoft Access 2013 - open and view the database. Not required but helpful for database verification during development.

Microsoft Access Redistributable 2010 - Database drivers for Microsoft Access. Required to run any applications that require the database (i.e. JavaServer and LifeBoardDisplayGui).

Samsung Kies - Hardware driver for Samsung Galaxy Tab 2 10.1 16GB so that application changes can be updated quickly on each tablet through Eclipse.

Android SDK 16 - Older version of Android that this system is developed to run on. Newer versions can be utilized but there are several updates that would be needed to make the system function properly on one.

Configuring a New Computer to Run and Develop the Lifeboard System

Configuring a new computer for this system can be very challenging depending on the machine and is not always successful. The first question to ask is what operating system is in use. If the new computer's system is Windows 7, everything for the system needs to be installed as their 32-bit versions, even if that installation of Windows 7 is the 64-bit version (install everything related to the project as 32-bit except the actual OS). This is because in Windows 7 Office is automatically configured as 32-bit meaning the Microsoft Access driver required for development and use must also be 32-bit. If the system is running Windows 8 everything can and

should be installed as 64-bit. It is highly recommended that the system is installed on a machine running Windows 8 due to the lack of conflict in architectures.

To configure a new computer, follow these general steps:

1) Install the latest version of the Android SDK - this is Eclipse with the Android plugin for it: http://developer.android.com/sdk/index.html?hl=sk

2) Install the project files by creating new projects and importing the files from file directory.

3) Install the Java JRE. The current system used Version 7 Rev 55; if a different version is used adjustments in the configuration of the projects in Eclipse will have to be made.

4) Install and configure Android-16 using the SDK manager at the top of Eclipse (green box with a white arrow pointing down). Additional configurations with this will have to be made with LifeBoard_App - make sure there isn't a red exclamation point over the project on the sidebar of Eclipse.

5) Configure 'lyfeboard.aacdb' as a database source by opening the ODBC Data Source Administrator (make sure it's the correct architecture version), and adding a new Microsoft Access Driver. If this isn't an option download Microsoft Access Redistributable 2010 and install it to get the drivers. Once you select the driver add a new User DSN. The name should be 'lyfeboard' and the Database should section should be directed to the file 'lyfeboard.aacdb'. Once this step is done everything should work. Note however that this is the trickiest step in the process and might need to be configured slightly different based on the machine. Refer to the console errors listed when running TCPServer.java for more details.

Code Commenting

Due to auto-refresh properties comments written in XML files are automatically removed after reloading the software so there are none of these in the programs. They are, however, very straightforward. Thorough comments have been added to MainActivity.java and EditArterialDialog.java for the Application. All java files named "Edit___Dialog.java" are very similar to one another and can easily be interpreted from each other. Additional comments have been placed into The Java Server programs as well.

A Note on Edit Functions in the System

This system's edit function is not currently configured to completely edit objects. Currently when edit is selected a brand new dialog is open where the previously entered information for that object is not already filled in. All information must be filled in and re-submitted. This issue

is due to the lack of proper storage and management of data in the system. The system was originally setup to manage data entries through ArrayLists of strings instead of Objects, meaning that once data is stored it is difficult to re-interpret it.

An additional issue with this resides in the editing and deleting of content in the system. Currently the database queries sent to the database do not compare timestamps due to the difficulty of obtaining these through the program (a significant overhaul is required for this) so if two entries are identical besides the timestamp and value (such as two applications of the same drug) then both of these entries will be edited or deleted.

II. Hardware

The Video Module is used for combining server and EKG displays into one. There is one DVI out connection that runs to the TV display, one VGA in connection that runs to the Server or EKG, and one DVI in connection for the other input source. DVI to VGA adapters are included with the video module. Use the Video Module's remote and enter its menu where it should be pretty straightforward changing the mode to Picture-in-Picture and moving the secondary screen into position.